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An Analysis of the Vertical Distribution of Ozone in the Atmosphere

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The Scientex Corporation
Washington, DC 20011

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December 31, 1980

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An analysis of vertical ozone distributions in the atmosphere is presented in tabular and graphical form for altitudes up to 25 kilometers. Histograms and concentrations probabilities are used to quantify the ozone distribution.

The analysis is limited to the consideration of the probabilities of ozone concentration occurrence obtained by lumping the data for all times and locations. Limitations are discussed, and recommendations are made with regard to further analysis for the determination of concentration variations with location and time.

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NOTATION

C	Degrees Celsius
K	Kelvin
k	Boltzmann's Constant (1.38×10^{-23} joules/K-molecule)
km	Kilometers
m	Meters
mbar	Millibars Pressure
N	Number of Molecules
nbar	Nanobars Pressure
P	Pressure
T	Temperature
V	Volume

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AN ANALYSIS OF THE VERTICAL DISTRIBUTION OF OZONE IN THE ATMOSPHERE

I. INTRODUCTION

While a great deal of data on the vertical distribution of ozone is available from the World Ozone Data Center (WODC) in Canada, little information is published on the probability of encountering a given ozone concentration at a particular altitude. In order to obtain at least an initial feel for the statistical distribution of ozone with altitude, it was decided to analyze the data on the Ozonesonde Observation data tape from the WODC[1*] to determine the probability of finding (or not finding) a given ozone concentration.

An ozonesonde in this context is an instrumented package which is sent up through the atmosphere, making periodic measurements of atmospheric pressure, ozone partial pressure, temperature, and (perhaps) wind speed and direction. The data tape has information from 4250 ozonesonde ascents, each of which has many data entries representing different altitudes, and covers the period 1962 to 1975 inclusive, as shown in Table 1. These observations were taken at 30 locations throughout the world, 25 of which are shown in Figure 1. Four of the remaining five locations are below 70^{0} south latitude and hence do not appear on the map, while the fifth location (not shown) is a ship which changes positions.

* Superscripts indicate references listed on page 11.

Manuscript submitted October 7, 1980.

II. THE DATA BASE

The data tape from the World Ozone Data Center contained 166,852 entries consisting of atmospheric pressure, ozone partial pressure, and temperature. Data reduction began by converting atmospheric pressure to altitude and ozone partial pressure to ozone concentration in a manner to be described in Section III. Next any entries which failed to meet the following criteria were rejected:

$$5\text{K} < \text{Temperature} < 373\text{K}$$

$$0.001\text{ km} < \text{Altitude} < 9990\text{ km}$$

$$0.1\text{ nbar} < \text{Ozone partial pressure} < \infty.$$

While the selection of limits was somewhat arbitrary, it was felt that any readings outside these limits were probably the result of equipment malfunction rather than an actual quantity. Table 2 shows the distribution of the rejected data entries by location, time of year, and rejection criteria. Of the 23,459 points rejected, 16,341 were rejected due to the temperature criterion (almost all from station 99), 6,431 due to the altitude criterion, and 699 due to the ozone criterion.

The remaining 143,393 data entries constitute the data base for this analysis. Table 3 shows the distribution of this data base by location and time of year. It can be seen that a significant amount of data has been gathered at most of the locations, and that, with few exceptions, the data were obtained throughout the year. Note, however, that the data cover a 14-year time span, and that three of the stations, Resolute (Canada), Aspendale (Australia), and Payerne (Switzerland), account for 45% of the data base.

III. DATA ANALYSIS

The analysis of the ozonesonde data consisted of several phases. First, data were transferred from magnetic tape to a digital computer file.* Next, altitude and ozone concentrations were computed from the raw data. Next, some of the entries were rejected as described previously, and the remaining 143,393 entries became the data base for this analysis. Finally, the computed parameters were organized into histograms and probability estimates to quantify ozone concentrations.

Altitude Determination

Total pressure was converted to altitude by comparing the local atmospheric pressure provided in the data base with a table of standard atmospheric pressure versus altitude[2] summarized in Table 4. Linear interpolation between table entries was used. Because the change in the pressure slope between entries was small, the interpolation error was minimal. The error at 1.5 kilometers, the area of maximum slope change, was less than 30 meters. For this limited study, no corrections were made for local variations in temperature or pressure.

Ozone Concentration Determination

For this study it was desired to express the ozone concentrations in terms of a molecular density (molecules/cubic meter). To accomplish this the ozone partial pressures in the data base were converted to molecular density using the equation of state of an ideal gas[3],

$$PV = NkT,$$

* For convenience, the data format on the magnetic tape is presented in Appendix A.

where: P = Ambient partial pressure of ozone (newton/m^2)

V = Volume (m^3)

N = Number of molecules of ozone

k = Boltzmann's constant (1.38×10^{-23} Joules/K-molecule)

T = Ambient temperature (K).

Since 1 bar = 10^5 newton/m^2, the above equation reduces to:

$$\text{Ozone concentration (molecules/m}^3) = 7.24\times10^{18}\ P(\text{nbar})/T(\text{K})$$

Ozone Concentration Histograms

Once the altitude and ozone concentration were determined, the data base was sorted by altitude and concentration, and the sorted data counted in preparation for making histograms. The sorted data is presented in Table 5, which shows the number of data entries recorded in each altitude and concentration band. For example, at altitudes between 10 and 11 kilometers, there were 132 data entries where the ozone concentration was between 1×10^{17} and 2×10^{17} molecules per cubic meter. The first part of Table 5 was then put into histograms showing the distribution of ozone for each altitude band. These histograms are presented in Appendix B.

Ozone Concentration Distributions

To begin evaluating the statistical distribution of ozone with altitude, the data from Table 5 were used to compute cumulative concentration probabilities for each altitude band. For the purpose of this analysis, the probability of an event is defined as the relative frequency of the event's occurrence in the data base. Hence, the altitude band cumulative probabilities were defined as the sum of all data entries up to the specified ozone concentration normalized by the total number of data entries

for the entire altitude band. To express the results in percentages, this number has been multiplied by 100.

The results of this analysis are shown in Table 6. As an example of the calculation procedure, consider the probability that the ozone concentration will be less than or equal to 5×10^{17} molecules per cubic meter for an altitude between 6 and 7 kilometers. From Table 5, the data entries in this altitude band are:

Ozone Concentration Limit (molecules/cubic meter)	Number of Data Entries
1×10^{17}	12
2×10^{17}	61
3×10^{17}	132
4×10^{17}	252
5×10^{17}	243

and the total number of data entries is 1,667. Therefore, the cumulative probability that the ozone concentration will be less than or equal to 5×10^{17} molecules per cubic meter is,

$$\text{Cumulative Probability} = \frac{12+61+132+252+243}{1{,}667} \times 100(\%)$$
$$= 41.99 \text{ or } 42\%$$

in agreement with Table 6.

Since the probability of exceeding a given ozone concentration was actually of more direct interest, the complements of the probabilities listed in Table 6 were analyzed further. The first step was to plot the probability of exceeding various ozone concentrations for each of the altitude bands. These curves are presented in Appendix C. Finally,

curves showing the probability of exceeding a specific ozone concentration as a function of altitude were prepared for various concentrations. These curves are shown in Figures 2 through 11.

IV. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The curves showing the probability of exceeding given ozone concentrations, which are presented in Figures 2 through 11, reveal several characteristics of the atmospheric ozone distribution up to an altitude of 25 kilometers. The ozone concentration is rarely greater than 15×10^{17} molecules per cubic meter below an altitude of 8 kilometers. Between 8 and 10 kilometers, however, all probability curves exhibit a significant increase in slope, indicating a rapid increase in ozone density. This rapid increase continues up to a point between 18 and 22 kilometers, depending on concentration level. The curves uniformly shift to the right as the concentration limit increases, and no curve reaches 100 percent probability at a concentration of 30×10^{17} molecules per cubic meter and above.

The results of the data analysis provide useful information regarding ozone concentrations. However, this study has two significant limitations:

- Data are lumped from all time periods and measurement locations.
- The data are not uniformly distributed geographically or temporally.

The first limitation means that variations in time and geographic location cannot be determined. The second limitation means that the results are biased toward locations and time intervals where most of the observations were made, for example, Resolute (Canada), Aspendale (Australia), and Payerne (Switzerland). Additional analyses are

necessary if these limitations are to be overcome and the applicability of the ozonesonde data base expanded. Specifically, it is recommended that a more detailed study be made, broadening the scope of the present effort by detailing variations in ozone concentration over time, by month, season or year, variations by latitude, and variations by specific locations around the world. Variations can be quantified by considering maximum and minimum values, and by a statistical measure such as the standard deviation. Once these variations are quantified, additional concentration probabilities can be established that account for their occurrence.

These additional analyses have several possible applications. Such applications may include:

- o The development of ozone concentration profiles to determine ambient ozone concentrations along aircraft flight patterns.
- o The determination of the amount of ozone along a line of sight for optical sensing studies.
- o The determination of the amount of ozone above or below a specific altitude.

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1. "Ozone Data for the World", World Meteorological Organization, World Ozone Data Center, 4905 Dufferin Street, Downsview, Ontario, M3H 5T4, Canada, 1962-1974.

2. "Handbook of Geophysics and Space Environments", S.L. Valley, Editor, Air Force Cambridge Laboratories, 1965, Table 2-5.

3. Sears, F.W. and M.W. Zemansky, University Physics, Second Edition, Reading, Massachusetts: Addison-Wesley Publishing Co., 1956, page 321.

Table 1 — Distribution of ozone soundings by station

STATION NUMBER	NUMBER OF SONDINGS	EARLIEST DATE	LATEST DATE
7	189	5 12 68	31 12 74
12	211	5 12 68	31 12 74
14	202	6 3 68	31 12 74
24	441	5 1 66	31 12 75
26	528	3 6 65	31 12 73
38	55	31 7 68	31 12 70
53	100	15 9 65	22 12 67
64	179	1 8 62	30 12 66
69	26	19 2 62	29 11 63
72	111	11 11 63	29 12 66
76	49	19 1 63	31 12 63
81	27	18 3 65	30 12 66
82	70	6 6 73	31 12 75
98	63	29 1 64	29 10 67
99	515	8 3 65	31 12 75
101	130	17 11 67	29 12 74
104	77	11 6 69	31 12 71
105	51	10 11 64	29 12 65
107	129	6 5 70	30 12 75
108	32	24 2 65	31 12 65
109	17	17 12 64	17 12 65
111	111	26 3 62	29 12 66
131	22	9 12 64	29 12 66
137	10	27 4 63	31 5 63
138	25	30 3 65	31 12 65
146	21	17 3 65	30 12 66
149	10	10 3 65	30 9 65
156	484	15 8 68	30 12 72
163	7	11 2 63	23 11 63
181	358	2 11 66	31 12 73

Table 2 — Distribution of rejected data by location and sampling date and by rejection criteria

STATION NUMBER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	ALT	UNKNOWN OZONE	TEMPER
7	27	26	21	30	24	18	28	22	26	23	18	32	295	288	7	0
12	35	31	28	27	10	24	28	26	24	24	31	30	318	310	8	0
14	27	23	30	47	31	32	8	9	25	29	42	23	326	322	4	0
24	59	68	65	73	70	52	51	64	28	52	38	57	677	674	3	0
26	31	25	25	34	44	34	28	37	42	52	39	26	417	415	2	0
38	1	4	5	6	4	3	25	5	6	7	11	4	81	80	1	0
53	13	36	24	34	21	33	16	37	33	0	30	25	302	205	93	4
64	25	26	54	25	20	82	34	29	21	16	12	21	365	319	45	1
69	0	4	7	11	4	3	1	3	10	8	28	0	79	62	17	0
72	10	14	16	12	8	24	18	10	27	14	17	32	202	202	0	0
76	7	10	4	9	23	4	4	6	12	9	5	5	98	67	29	2
81	0	0	4	0	2	3	3	0	5	11	9	26	63	61	2	0
82	8	3	11	9	8	19	12	12	9	6	8	34	139	135	2	2
98	3	41	32	8	9	0	0	0	0	3	0	0	96	93	1	2
99	1711	1472	1544	1759	1519	1355	1264	1351	1296	1215	1337	1411	17234	766	147	16321
101	12	8	9	13	5	9	25	13	22	40	41	17	214	211	3	0
104	8	10	35	7	2	6	6	14	15	22	19	21	165	141	24	0
105	6	6	6	3	7	11	10	5	8	6	12	33	113	112	1	0
107	18	16	20	15	16	18	11	20	25	26	19	19	223	205	13	5
108	0	1	7	0	3	3	6	3	5	3	0	15	46	45	1	0
109	0	0	2	3	0	10	0	4	4	1	1	16	41	41	0	0
111	2	18	24	15	7	25	16	9	20	19	16	36	207	203	3	1
131	11	5	6	2	3	5	8	0	0	0	0	8	48	47	1	0
137	0	0	0	3	18	0	0	0	0	0	0	0	21	21	0	0
138	0	0	6	0	0	8	2	4	14	4	2	12	52	51	1	0
146	0	0	5	16	0	1	0	0	4	3	2	3	34	34	0	0
149	0	0	3	1	3	2	1	2	6	0	0	0	18	12	6	0
156	56	62	56	74	57	53	73	56	51	64	73	69	744	742	14	0
163	0	2	3	0	0	0	0	0	3	3	4	0	15	15	0	0
181	119	66	79	72	72	62	61	55	66	40	74	60	826	552	271	3
TOTAL	2189	1977	2131	2308	1990	1899	1739	1796	1807	1700	1888	2035	23459	6431	699	16341

Table 3 — Distribution of data base by location and sampling date

STATION NUMBER	LONG	LAT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	LOCATION
7	130E	32N	665	446	499	502	488	410	452	394	386	425	378	432	5477	KAGOSHIMA,JAPAN
12	141E	43N	685	737	764	621	510	516	636	502	480	636	669	674	7430	SAPPORO,JAPAN
14	140E	36N	621	585	1034	825	737	440	112	103	443	571	642	529	6642	TATENO,JAPAN
24	95W	75N	1253	1836	1911	1919	1446	972	1233	1224	948	1124	1054	999	15919	RESOLUTE,CAN
26	145E	38S	2081	1947	2259	1882	2360	2562	2576	2787	3030	3792	2445	2366	30087	ASPENDALE,AUSTR
38	9E	39N	59	112	299	390	280	145	347	199	198	285	289	216	2819	ELMAS,ITALY
53	4E	51N	63	252	280	302	347	243	200	307	351	0	86	155	2586	UCCLE,BELGIUM
64	77W	39N	403	566	1426	1131	784	1494	614	491	383	308	164	371	8135	STERLING,U.S.
69	170E	72S	0	68	101	137	44	25	23	37	90	84	48	0	657	HALLETT, (ANT)
72	110W	80S	322	370	364	368	120	288	330	170	397	326	331	336	3722	BYRD,(ANT)
76	60W	53N	97	110	116	167	325	120	96	70	120	115	75	23	1434	GOOSE,CAN
81	24E	70S	28	0	52	40	26	57	29	28	83	165	199	106	813	BASE KING,(ANT)
82	9W	39N	336	241	473	555	396	481	476	436	167	246	216	430	4453	LISBON,PORT
98	2E	49N	29	303	192	92	55	0	0	0	0	13	0	0	684	VAL JOYEUX(PARIS)
99	11E	48N	513	460	764	481	557	669	368	569	688	553	539	657	6818	HOHENPEISSENBUERG,W GER
101	39E	69S	320	180	179	311	127	159	371	195	438	784	607	395	4066	SYOWA,(ANT)
104	71W	42N	364	234	313	177	154	198	222	290	273	382	273	319	3199	BEDFORD,MASS
105	148W	65N	82	66	158	73	81	137	114	83	116	94	204	275	1483	FAIRBANKS,ALASKA
107	75W	38N	258	268	304	125	236	354	173	216	315	354	249	297	3149	WALLOPS IS,VIRGINIA
108	171W	3S	0	15	93	24	69	97	46	65	99	53	48	153	762	CANTON IS,U.S.
109	155W	20N	0	0	50	29	0	118	24	52	72	27	23	48	443	HILO,HAWAII
111	24W	90S	90	438	408	365	265	311	168	163	420	425	336	304	3693	AMUNDSEN-SCOTT(ANT)
131	73W	41S	141	59	90	30	29	83	88	0	0	0	28	84	632	PUERTO MONTT,CHILE
137	95W	39N	0	0	0	21	254	0	0	0	0	0	0	0	275	TOPEKA,KANSAS
138	172E	43S	0	0	54	0	0	92	46	48	150	44	22	88	544	CHRISTCHURCH,N.Z.
146	SHIP	SHIP	0	0	143	144	0	51	0	0	56	85	66	81	626	USNS ELTANIN
149	68W	17S	0	0	25	27	37	54	23	58	54	0	0	0	278	LA PAZ,BOLIVIA
156	7E	47N	1252	1678	1764	1738	1643	15[illegible]	1779	1372	1269	1552	1639	1483	18692	PAYERNE,SWITZERLAND
163	110E	66S	0	42	33	0	0	0	0	24	25	53	20	0	197	WILKES(ANT)
181	13E	42N	837	634	837	928	804	722	507	401	562	404	534	508	7678	BERLIN, W GER
	TOTALS		10499	11647	14985	13404	12174	12321	11053	10284	11613	12900	11184	11329	143393	

Table 4 — Pressure and temperature of the U. S. standard atmosphere versus altitude[2]

Altitude (km)	Temperature (^{o}C)	Pressure (mbar)
0	15.0	1013.25
1	8.5	898.76
2	2.0	795.01
3	- 4.5	701.21
4	-11.0	616.60
5	-17.5	540.48
6	-24.0	472.18
7	-30.5	411.05
8	-36.9	356.52
9	-43.4	308.01
10	-49.9	265.00
11	-56.4	227.00
12	-56.5	193.99
13	-56.5	165.80
14	-56.5	141.70
15	-56.5	121.12
16	-56.5	103.53
17	-56.5	88.50
18	-56.5	75.65
19	-56.5	64.67
20	-56.5	55.29
21	-55.6	47.29
22	-54.6	40.47
23	-53.6	34.67
24	-52.6	29.72
25	-51.6	25.49

Table 5 — Distribution of the data base by altitude band and ozone concentration band

Ozone Concentration* (10^{17} molecules/cubic meter)

Number of Observations

ALTITUDE* (km) / OZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25+	TOTAL
01	350	48	7	35	12	42	12	15	16	74	26	54	11	35	11	18	7	0	0	0	0	0	0	0	0	18	791
02	455	83	18	123	33	162	61	125	59	229	132	154	53	69	21	20	30	1	0	0	0	0	0	0	0	26	1854
03	488	138	37	227	95	325	132	249	213	463	253	228	87	135	58	38	43	2	0	2	1	0	0	1	0	50	3265
04	621	199	108	340	173	465	252	482	298	665	360	343	156	201	116	54	67	7	1	0	0	1	0	1	0	77	4987
05	703	255	134	449	249	550	243	399	269	663	311	330	160	227	128	78	79	16	4	3	0	0	2	0	0	99	5351
06	891	418	339	729	419	758	276	412	268	617	313	355	183	278	200	123	94	21	5	1	3	0	0	0	0	123	6826
07	1001	590	363	885	453	755	212	310	168	462	246	299	188	270	191	152	137	24	3	1	3	0	0	1	0	126	6840
08	776	578	334	753	322	615	144	229	168	401	186	288	168	259	201	144	146	26	9	1	1	0	0	0	2	170	5921
09	504	358	175	587	198	333	100	129	111	265	161	245	156	177	177	123	138	32	10	1	3	0	0	3	0	217	4203
10	403	306	136	433	137	235	65	100	87	219	162	225	171	232	180	190	143	55	14	3	4	0	0	4	0	262	3766
11	279	230	109	292	79	161	48	69	62	205	118	218	166	223	211	188	189	74	25	0	3	1	0	4	5	350	3309
12	191	141	66	176	44	96	28	35	58	145	142	200	144	229	174	167	177	81	15	3	3	0	0	4	6	372	2697
13	142	88	42	92	29	49	13	30	57	105	120	187	116	190	152	150	201	76	25	3	3	4	1	11	6	417	2309
14	108	69	22	43	14	25	21	30	46	100	100	214	165	202	198	156	196	93	46	10	7	2	2	7	10	494	2380
15	87	47	17	22	9	16	14	25	37	91	104	166	138	215	159	180	238	113	54	5	3	3	7	13	14	521	2298
16	65	36	12	12	8	8	10	17	31	111	110	199	132	198	207	158	248	110	67	10	4	0	4	19	10	528	2314
17	24	18	8	12	4	7	8	12	29	75	75	174	141	191	179	144	238	139	98	10	7	6	8	24	13	555	2199
18	19	13	3	5	3	3	5	9	23	82	78	159	116	175	144	147	205	111	84	15	9	9	8	21	11	486	1943
19	21	10	2	6	1	8	4	8	16	64	81	152	137	181	156	146	251	154	127	30	17	14	12	34	10	612	2254
20	13	6	2	5	2	1	2	9	14	57	99	163	112	173	144	130	195	155	157	36	18	10	17	32	14	572	2138
21	14	2	2	2	0	2	4	7	14	67	67	155	125	165	138	147	220	151	165	54	19	6	18	25	13	644	2226
22	6	1	3	2	0	0	0	6	10	37	64	128	106	172	132	118	191	142	142	50	19	10	15	38	15	607	2014
23	2	0	1	2	1	2	4	2	11	47	61	140	106	138	124	125	183	156	213	90	27	17	17	27	10	682	2188
24	3	3	0	1	1	4	1	1	13	31	57	140	133	161	127	134	208	179	235	96	33	23	31	32	18	702	2367
25	4	0	2	0	2	1	1	2	6	29	70	116	106	136	107	113	167	150	223	117	62	31	29	40	13	744	2271
26	2	4	0	2	0	0	0	5	11	20	48	116	80	153	120	97	148	121	194	101	59	30	27	57	19	608	2022
27	1	1	0	0	1	0	1	0	11	36	40	109	101	139	107	105	162	158	230	124	108	33	33	59	26	724	2309
28	7	0	1	1	1	3	0	2	7	35	50	116	82	151	109	126	160	159	269	144	131	62	55	58	38	713	2480
29	1	0	0	1	0	1	1	2	4	25	44	102	82	145	110	98	174	169	261	128	145	67	55	72	43	742	2472
30	1	0	0	0	0	0	2	3	6	18	32	86	68	118	103	108	139	131	242	163	178	96	81	78	51	707	2411
31	3	0	0	0	1	0	0	1	5	22	34	65	68	110	84	101	121	120	210	153	155	98	76	90	72	610	2199
32	1	0	0	0	0	1	0	1	4	19	31	70	66	112	80	82	151	130	239	174	228	112	116	116	92	744	2569
33	0	0	0	0	0	0	1	1	4	13	29	71	67	107	80	90	135	151	217	186	248	135	155	141	114	639	2584
34	3	0	0	0	0	0	0	0	4	18	25	68	59	90	81	91	141	113	198	176	279	135	160	163	114	640	2558
35	0	0	0	0	0	0	0	1	1	20	27	59	59	87	67	85	114	112	195	158	231	117	132	146	112	511	2234
36	0	0	0	0	0	0	0	0	4	16	33	58	45	87	65	84	135	116	219	171	261	140	184	185	181	572	2556
37	0	0	0	0	0	0	0	1	3	13	29	57	53	85	81	60	131	125	189	144	259	134	218	204	170	544	2500
38	1	0	0	0	0	0	0	1	2	12	32	46	35	71	47	71	119	86	180	127	240	156	223	220	189	515	2373
39	0	0	0	1	0	0	0	1	2	8	26	47	32	67	54	47	128	87	163	128	194	144	186	206	139	395	2055
40	1	0	0	0	0	0	1	0	2	7	24	47	37	53	35	66	105	86	157	141	221	146	249	230	161	360	2129
41	1	0	0	0	0	0	0	1	1	9	13	52	42	63	39	64	97	85	188	116	202	161	216	217	154	330	2051
42	0	0	0	0	0	0	0	0	2	6	13	40	35	56	40	68	118	75	133	123	216	151	196	215	140	306	1933
43	0	0	0	0	0	0	1	0	1	7	12	43	28	51	38	50	100	95	134	112	206	121	191	201	130	277	1798
44	1	0	0	0	0	0	0	0	0	11	14	41	34	51	58	54	89	70	128	86	151	119	149	215	99	254	1624
45	0	0	0	0	0	0	0	0	0	8	12	39	34	40	40	52	87	73	117	108	193	143	193	243	117	205	1704
46	0	0	0	0	0	0	0	0	2	10	17	34	26	40	53	62	97	72	122	95	206	121	159	213	84	188	1601
47	0	0	0	0	0	0	0	0	0	6	7	22	22	50	41	47	78	62	141	98	187	108	149	183	84	160	1445
48	0	0	0	0	0	0	0	0	1	6	12	33	28	52	42	44	62	70	75	75	187	114	132	171	61	150	1315
49	0	0	0	0	0	0	0	0	1	2	5	21	21	30	28	39	79	59	103	57	157	103	147	181	53	95	1181
50	0	0	0	0	0	0	0	0	0	1	15	37	28	25	39	26	55	57	95	70	134	99	122	186	57	97	1143

* Number shown is upper limit of the band. The lower limit is implied. For example, n = 20 means $19 < n \le 20$.

Table 5 (Continued) — Distribution of the data base by altitude band and ozone concentration band

Ozone Concentration* (10^{17} molecules/cubic meter)

Number of Observations

Altitude* (km)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25+	TOTAL
OZONE																											
51	0	0	0	0	0	0	0	0	0	2	13	30	23	37	37	32	56	45	83	59	126	77	126	139	53	59	997
52	0	0	0	0	0	0	0	0	0	5	10	26	26	33	35	45	75	52	94	46	114	87	87	131	41	46	953
53	0	0	0	0	0	0	0	0	0	4	10	23	21	43	24	42	72	44	77	66	139	83	96	125	28	33	930
54	0	0	0	0	0	0	0	0	0	4	6	15	12	22	27	39	60	54	81	51	116	57	81	97	27	24	773
55	0	0	0	0	0	0	0	0	0	1	3	19	25	25	27	36	55	57	82	50	103	84	53	99	29	20	768
56	0	0	0	0	0	0	0	0	1	2	7	21	19	26	36	29	59	36	69	52	109	63	64	78	22	13	706
57	0	0	0	0	0	0	0	0	0	1	4	16	15	31	25	34	36	34	59	53	102	56	50	74	18	10	618
58	0	0	0	0	0	0	0	0	0	0	2	10	12	29	21	26	34	41	61	43	83	49	46	71	10	6	544
59	0	0	0	0	0	0	0	0	0	0	3	11	16	17	23	33	33	46	69	47	85	37	48	50	11	5	534
60	0	0	0	0	0	0	0	0	0	1	3	11	14	20	17	20	43	33	49	26	71	53	31	42	6	8	448
61	0	0	0	0	0	0	0	0	0	0	3	12	9	18	23	22	36	32	49	29	55	41	27	49	9	7	421
62	0	0	0	0	0	0	0	0	0	1	5	7	9	15	15	34	40	22	63	41	56	29	25	25	8	1	396
63	0	0	0	0	0	0	0	0	0	0	3	7	8	16	20	27	49	32	37	33	56	26	25	19	0	3	361
64	0	0	0	0	0	0	0	0	0	1	2	7	9	13	26	21	35	32	51	44	50	35	27	18	2	1	374
65	0	0	0	0	0	0	0	0	1	0	0	9	12	18	11	21	27	30	41	26	59	32	29	22	2	2	342
66	0	0	0	0	0	0	0	0	0	0	2	8	7	12	7	18	42	27	45	27	46	25	16	13	0	4	299
67	0	0	0	0	0	0	0	0	0	0	1	4	8	18	12	17	31	25	52	25	45	26	15	12	0	3	294
68	0	0	0	0	0	1	0	0	0	0	0	6	5	17	14	23	32	22	42	23	37	25	13	7	2	3	272
69	0	0	0	0	0	0	0	0	0	0	0	2	11	11	14	16	21	26	37	18	29	24	9	11	3	1	233
70	0	0	0	0	0	0	0	0	0	0	1	1	7	14	18	15	26	20	33	17	37	22	12	7	0	1	231
71	0	0	0	0	0	0	0	0	0	0	0	0	3	14	16	18	22	16	32	15	25	18	8	4	0	2	193
72	0	0	0	0	0	0	0	0	0	0	0	2	3	8	9	7	18	18	28	15	34	10	9	8	0	2	171
73	0	0	0	0	0	0	0	0	0	0	0	3	6	9	14	13	25	20	29	11	33	13	6	3	0	3	188
74	0	0	0	0	0	0	0	0	0	0	0	0	5	16	9	10	15	14	26	15	31	12	13	1	1	2	170
75	0	0	0	0	0	0	0	0	0	0	0	2	2	13	10	11	21	14	20	12	21	4	3	3	0	1	137
76	0	0	0	0	0	0	0	0	0	0	0	0	2	10	14	14	13	14	28	9	27	9	2	7	1	2	152
77	0	0	0	0	0	0	0	0	0	0	0	0	4	7	10	16	11	16	19	13	27	11	4	1	0	1	140
78	0	0	0	0	0	0	0	0	0	0	0	0	9	9	9	10	12	15	21	15	22	6	2	1	0	0	131
79	0	0	0	0	0	0	0	0	0	0	0	0	5	4	13	7	22	17	17	16	19	4	4	0	0	0	128
80	0	0	0	0	0	0	0	0	0	0	0	1	1	14	10	11	18	9	15	20	14	5	3	0	0	0	121
81	0	0	0	0	0	0	0	0	0	0	0	0	4	8	6	9	12	14	13	7	14	3	1	0	0	1	92
82	0	0	0	0	0	0	0	0	0	0	0	0	5	12	7	11	18	11	12	15	10	1	0	1	0	2	105
83	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	8	10	14	13	9	4	5	1	2	0	0	76
84	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	8	10	11	10	5	5	2	1	0	0	2	64
85	0	0	0	0	0	0	0	0	0	0	0	0	4	6	9	11	10	13	11	8	5	3	0	1	0	0	81
86	0	0	0	0	0	0	0	0	0	0	0	0	1	5	3	4	20	16	10	8	4	3	2	3	0	0	79
87	0	0	0	0	0	0	0	0	0	0	0	0	2	6	4	5	8	12	11	9	5	3	0	0	2	0	67
88	0	0	0	0	0	0	0	0	0	0	0	0	4	3	12	7	8	18	13	4	5	0	1	0	0	1	76
89	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	8	9	7	16	6	4	0	2	1	0	0	62
90	0	0	0	0	0	0	0	0	0	0	0	0	2	6	5	12	8	6	12	3	3	1	0	0	1	0	59
91	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	12	8	13	5	4	2	1	0	0	0	0	54
92	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	6	6	13	7	8	3	2	1	1	0	0	53
93	0	0	0	0	0	0	0	0	0	0	0	0	0	4	6	4	7	7	7	3	4	1	0	1	0	0	44
94	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	10	8	8	3	0	2	0	0	0	0	36
95	0	0	0	0	0	0	0	0	0	0	0	0	0	4	6	7	14	2	9	2	2	1	0	0	0	0	47
96	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	5	4	5	6	4	3	0	0	2	0	0	35
97	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	4	8	2	3	1	3	0	0	1	0	1	30
98	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	4	6	8	5	3	2	1	0	0	0	0	36
99	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	3	7	5	3	2	0	0	0	0	0	0	28
100	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	2	5	9	4	3	1	0	3	0	1	0	34
100+	0	0	0	0	0	0	0	0	0	1	0	0	1	11	32	47	57	27	29	11	15	4	7	5	0	6	253

* Number shown is upper limit of the band. The lower limit is implied. For example, n = 20 means 19 < n ≤ 20.

Table 5 (Continued) — Distribution of the data base by altitude band and ozone concentration band

Altitude* (km)	Total Data Entries
01	7193
02	3642
03	1943
04	5238
05	2291
06	4629
07	1667
08	2732
09	2164
10	5675
11	4198
12	6764
13	4846
14	7293
15	5961
16	5807
17	8200
18	5734
19	7737
20	4734
21	6890
22	4038
23	4728
24	5526
25	2947
25+	20816
TOT	143393

* Number shown is upper limit of the band. The lower limit is implied. For example, n = 20 means $19 < n \leq 20$.

Table 6 — Cumulative probability that ozone concentration will be less than designated value for each altitude band

Cumulative Probability (percent)

Ozone Concentration Limit (10^{17} molecules/cubic meter)

Altitude* (km)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25+
OZONE																										
01	5	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02	11	4	1	3	2	4	4	5	3	5	4	3	1	1	1	1	0	0	0	0	0	0	0	0	0	0
03	18	7	3	7	6	11	12	14	13	13	10	6	3	3	2	1	1	0	0	0	0	0	0	0	0	0
04	27	13	9	14	14	21	27	32	27	25	18	12	6	6	3	2	2	0	0	0	0	0	0	0	0	1
05	36	20	16	22	25	33	42	46	40	37	26	16	10	9	6	4	3	0	0	0	0	0	0	0	0	1
06	49	31	33	36	43	50	59	62	52	48	33	22	13	13	9	6	4	1	0	0	0	0	0	0	0	2
07	63	48	52	53	63	66	71	73	60	56	39	26	17	17	12	8	6	1	0	0	0	0	0	0	0	2
08	73	63	69	68	77	79	80	81	67	63	44	30	21	20	16	11	7	2	0	0	0	0	0	0	0	3
09	80	73	78	79	85	87	86	86	73	68	47	34	24	23	19	13	9	2	0	0	0	0	0	0	0	4
10	86	82	85	87	91	92	90	90	77	72	51	37	28	26	22	16	11	3	1	0	0	0	0	0	0	6
11	90	88	91	93	95	95	93	92	79	75	54	40	31	29	25	19	13	4	1	0	0	0	0	0	0	7
12	93	92	94	96	97	97	94	93	82	78	57	43	34	32	28	22	15	6	1	0	0	0	0	0	0	9
13	95	94	96	98	98	98	95	95	85	80	60	46	36	35	31	25	18	7	1	0	0	0	0	1	1	11
14	96	96	97	99	99	99	96	96	87	81	63	49	40	37	34	28	20	9	2	1	0	0	0	1	1	13
15	97	97	98	99	99	99	97	97	89	83	65	52	43	40	37	31	23	11	3	1	0	0	0	1	1	16
16	98	98	99	99	99	99	98	97	90	85	68	55	45	43	40	33	26	13	4	1	1	0	0	1	2	18
17	99	99	99	99	99	99	98	98	91	86	70	57	48	46	43	36	29	15	5	1	1	0	1	2	2	21
18	99	99	99	100	100	99	99	98	92	88	71	60	51	48	45	38	31	17	6	1	1	1	1	2	3	23
19	99	100	99	100	100	100	99	98	93	89	73	62	53	51	48	41	34	20	8	2	1	1	1	3	3	26
20	99	100	100	100	100	100	99	99	94	90	76	64	56	53	50	43	37	22	10	3	1	1	1	3	3	29
21	99	100	100	100	100	100	99	99	94	91	77	67	58	55	53	46	40	25	12	4	2	1	2	4	4	32
22	100	100	100	100	100	100	99	99	95	92	79	69	60	58	55	48	42	28	14	5	2	2	2	4	4	35
23	100	100	100	100	100	100	99	99	95	92	80	71	63	59	57	50	44	30	16	7	2	2	2	5	5	38
24	100	100	100	100	100	100	100	99	96	93	82	73	65	62	59	52	47	33	19	9	3	3	3	5	5	42
25	100	100	100	100	100	100	100	99	96	93	83	74	68	64	61	54	49	36	22	11	4	3	4	6	6	45
26	100	100	100	100	100	100	100	99	97	94	84	76	69	66	63	56	50	38	25	14	4	4	4	7	6	48
27	100	100	100	100	100	100	100	99	97	94	85	78	71	68	65	58	52	41	28	16	6	5	5	8	7	52
28	100	100	100	100	100	100	100	100	98	95	87	79	73	70	67	60	54	44	31	19	8	6	6	9	9	55
29	100	100	100	100	100	100	100	100	98	96	88	81	75	72	68	61	57	47	35	22	10	8	7	11	10	59
30	100	100	100	100	100	100	100	100	98	96	88	82	76	73	70	63	58	49	38	25	13	11	9	12	12	62
31	100	100	100	100	100	100	100	100	98	96	89	83	78	75	72	65	60	51	40	29	15	13	11	14	14	65
32	100	100	100	100	100	100	100	100	99	97	90	84	79	76	73	66	62	53	44	32	18	16	13	16	17	69
33	100	100	100	100	100	100	100	100	99	97	91	85	80	78	74	68	63	56	46	36	22	19	16	18	21	72
34	100	100	100	100	100	100	100	100	99	97	91	86	81	79	76	70	65	58	49	40	26	22	20	21	25	75
35	100	100	100	100	100	100	100	100	99	97	92	87	83	80	77	71	66	60	51	43	29	25	22	24	29	77
36	100	100	100	100	100	100	100	100	99	98	93	88	84	81	78	72	68	62	54	47	33	29	26	27	35	80
37	100	100	100	100	100	100	100	100	99	98	93	89	85	82	79	74	70	64	57	50	37	32	31	31	41	83
38	100	100	100	100	100	100	100	100	99	98	94	90	85	83	80	75	71	66	59	53	40	36	36	35	47	85
39	100	100	100	100	100	100	100	100	99	98	95	90	86	84	81	76	73	67	61	55	43	40	40	39	52	87
40	100	100	100	100	100	100	100	100	100	98	95	91	87	85	81	77	74	69	63	58	46	43	45	43	57	89
41	100	100	100	100	100	100	100	100	100	99	96	92	88	86	82	78	75	70	66	61	49	47	49	47	63	90
42	100	100	100	100	100	100	100	100	100	99	96	92	88	87	83	79	76	71	67	63	52	51	54	51	67	92
43	100	100	100	100	100	100	100	100	100	99	96	93	89	87	83	80	78	73	69	66	55	54	58	54	72	93
44	100	100	100	100	100	100	100	100	100	99	97	94	90	88	84	81	79	74	71	68	57	57	61	58	75	94
45	100	100	100	100	100	100	100	100	100	99	97	94	90	89	85	82	80	76	72	70	60	60	65	63	79	95
46	100	100	100	100	100	100	100	100	100	99	97	95	91	89	86	83	81	77	74	72	63	63	68	66	82	96
47	100	100	100	100	100	100	100	100	100	99	97	95	91	90	87	84	82	78	76	74	66	66	71	70	85	97
48	100	100	100	100	100	100	100	100	100	100	98	95	92	91	87	84	83	79	77	75	69	69	74	73	87	98
49	100	100	100	100	100	100	100	100	100	100	98	96	92	91	88	85	84	80	78	77	71	71	77	76	89	98
50	100	100	100	100	100	100	100	100	100	100	98	96	93	91	89	85	84	81	79	78	73	74	80	79	91	99

* Number shown is upper limit of the band. The lower limit is implied. For example, n = 20 means $19 < n \leq 20$.

Table 6 (Continued) — Cumulative probability that ozone concentration will be less than designated value for each altitude band

Ozone Concentration Limit (10^{17} molecules/cubic meter) vs. Cumulative Probability (percent)

Altitude* (km)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25+
OZONE																										
51	100	100	100	100	100	100	100	100	100	100	98	97	93	92	89	86	85	82	80	79	75	76	83	82	92	99
52	100	100	100	100	100	100	100	100	100	100	99	97	94	92	90	87	86	83	81	80	76	78	84	84	94	99
53	100	100	100	100	100	100	100	100	100	100	99	97	94	93	90	87	87	84	82	82	78	80	86	87	95	99
54	100	100	100	100	100	100	100	100	100	100	99	98	95	93	91	88	88	84	83	83	80	81	88	88	96	99
55	100	100	100	100	100	100	100	100	100	100	99	98	95	94	91	89	88	85	85	84	82	83	89	90	97	100
56	100	100	100	100	100	100	100	100	100	100	99	98	96	94	92	89	89	86	85	85	83	85	91	92	97	100
57	100	100	100	100	100	100	100	100	100	100	99	98	96	94	92	90	89	87	86	86	85	86	92	93	98	100
58	100	100	100	100	100	100	100	100	100	100	99	99	96	95	92	90	90	87	87	87	86	88	93	94	98	100
59	100	100	100	100	100	100	100	100	100	100	100	99	97	95	93	91	90	88	88	88	87	89	94	95	99	100
60	100	100	100	100	100	100	100	100	100	100	100	99	97	95	93	91	91	89	88	89	88	90	94	96	99	100
61	100	100	100	100	100	100	100	100	100	100	100	99	97	96	93	92	91	89	89	89	89	91	95	97	99	100
62	100	100	100	100	100	100	100	100	100	100	100	99	97	96	94	92	92	90	90	90	90	92	95	97	99	100
63	100	100	100	100	100	100	100	100	100	100	100	99	97	96	94	93	92	90	90	91	91	92	96	98	99	100
64	100	100	100	100	100	100	100	100	100	100	100	99	98	96	94	93	93	91	91	92	91	93	96	98	100	100
65	100	100	100	100	100	100	100	100	100	100	100	100	98	96	95	93	93	91	92	92	92	94	97	98	100	100
66	100	100	100	100	100	100	100	100	100	100	100	100	98	97	95	94	94	92	92	93	93	95	97	98	100	100
67	100	100	100	100	100	100	100	100	100	100	100	100	98	97	95	94	94	92	93	93	93	95	98	99	100	100
68	100	100	100	100	100	100	100	100	100	100	100	100	98	97	95	94	94	93	93	94	94	96	98	99	100	100
69	100	100	100	100	100	100	100	100	100	100	100	100	98	97	95	95	95	93	94	94	94	96	98	99	100	100
70	100	100	100	100	100	100	100	100	100	100	100	100	99	97	96	95	95	93	94	95	95	97	98	99	100	100
71	100	100	100	100	100	100	100	100	100	100	100	100	99	98	96	95	95	94	95	95	95	97	99	99	100	100
72	100	100	100	100	100	100	100	100	100	100	100	100	99	98	96	95	95	94	95	95	96	98	99	99	100	100
73	100	100	100	100	100	100	100	100	100	100	100	100	99	98	96	96	96	94	95	95	96	98	99	99	100	100
74	100	100	100	100	100	100	100	100	100	100	100	100	99	98	97	96	96	95	96	96	97	98	99	99	100	100
75	100	100	100	100	100	100	100	100	100	100	100	100	99	98	97	96	96	95	96	96	97	98	99	100	100	100
76	100	100	100	100	100	100	100	100	100	100	100	100	99	98	97	96	96	95	96	96	97	99	99	100	100	100
77	100	100	100	100	100	100	100	100	100	100	100	100	99	98	97	96	96	95	97	96	98	99	99	100	100	100
78	100	100	100	100	100	100	100	100	100	100	100	100	99	99	97	97	97	96	97	97	98	99	99	100	100	100
79	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	97	97	96	97	97	98	99	100	100	100	100
80	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	97	97	96	97	98	99	99	100	100	100	100
81	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	97	97	96	97	98	99	99	100	100	100	100
82	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	97	97	97	98	98	99	99	100	100	100	100
83	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	97	98	97	98	98	99	99	100	100	100	100
84	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	98	98	97	98	98	99	99	100	100	100	100
85	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	98	98	97	98	98	99	100	100	100	100	100
86	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	98	98	98	98	99	99	100	100	100	100	100
87	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	98	98	98	98	99	99	100	100	100	100	100
88	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	98	98	99	99	99	100	100	100	100	100
89	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	98	98	99	99	99	100	100	100	100	100
90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	98	98	98	99	99	99	100	100	100	100	100
91	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	99	99	99	100	100	100	100	100	100
92	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	100	100	100	100	100	100
93	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	100	100	100	100	100	100
94	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	100	100	100	100	100	100
95	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	100	100	100	100	100	100
96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	100	100	100	100	100	100	100
97	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	100	100	100	100	100	100	100
98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	100	100	100	100	100	100	100	100
99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	100	100	100	100	100	100	100	100	100

* Number shown is upper limit of the band. The lower limit is implied. For example, n = 20 means $19 < n \leq 20$.

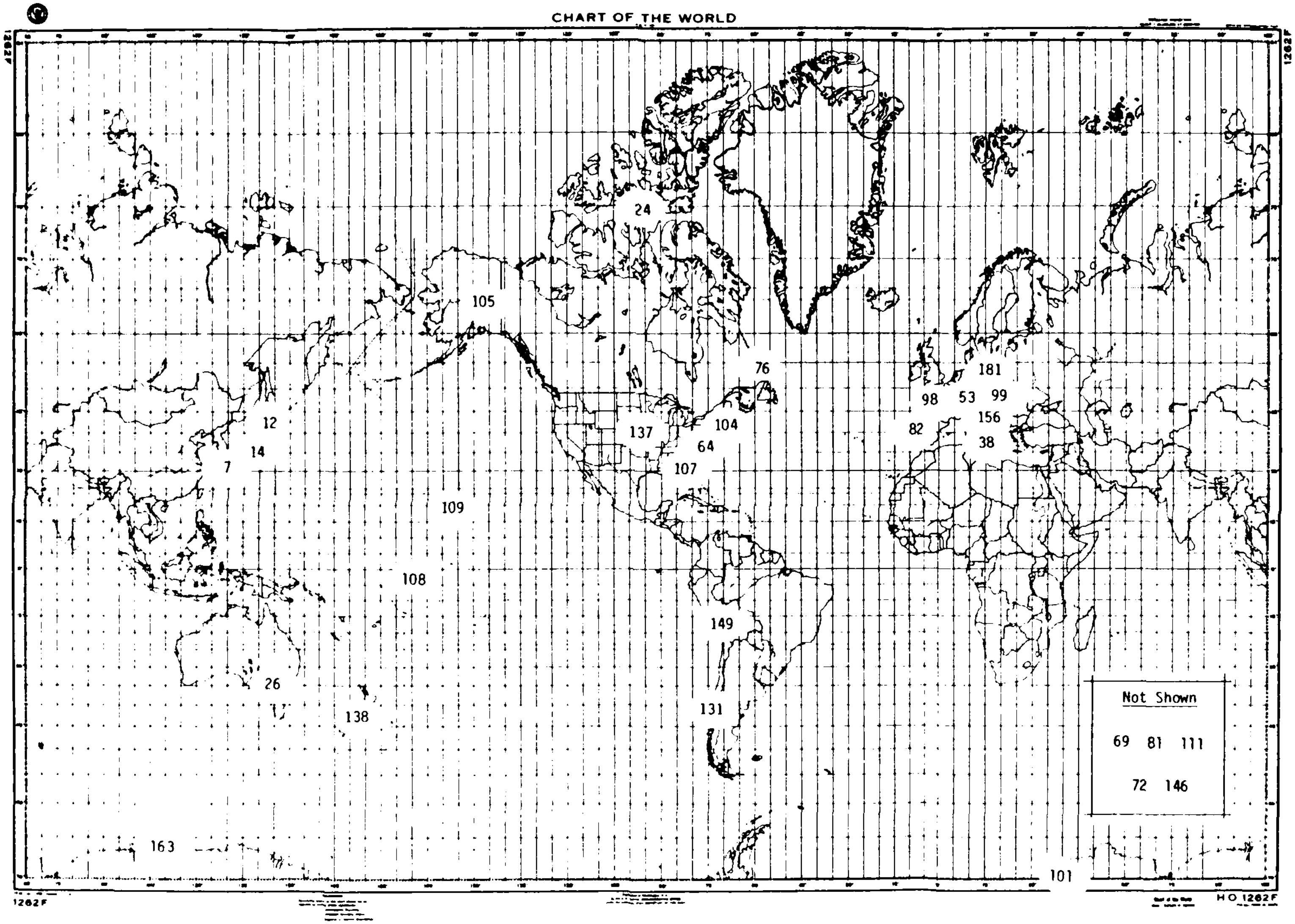

Fig. 1 — Ozonesonde data base station locations

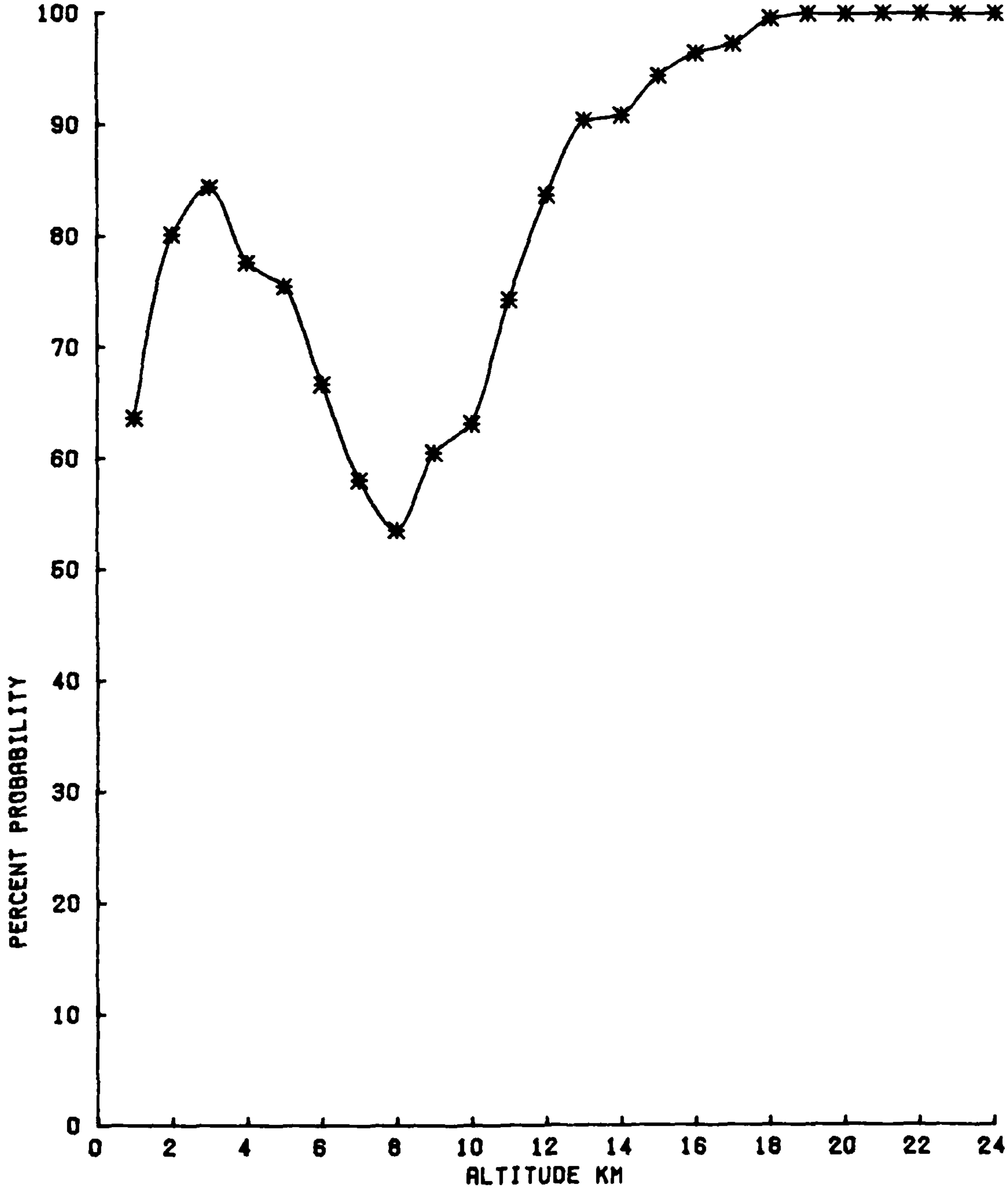

Fig. 2 — Probability of exceeding an ozone concentration of 5×10^{17} molecules per cubic meter

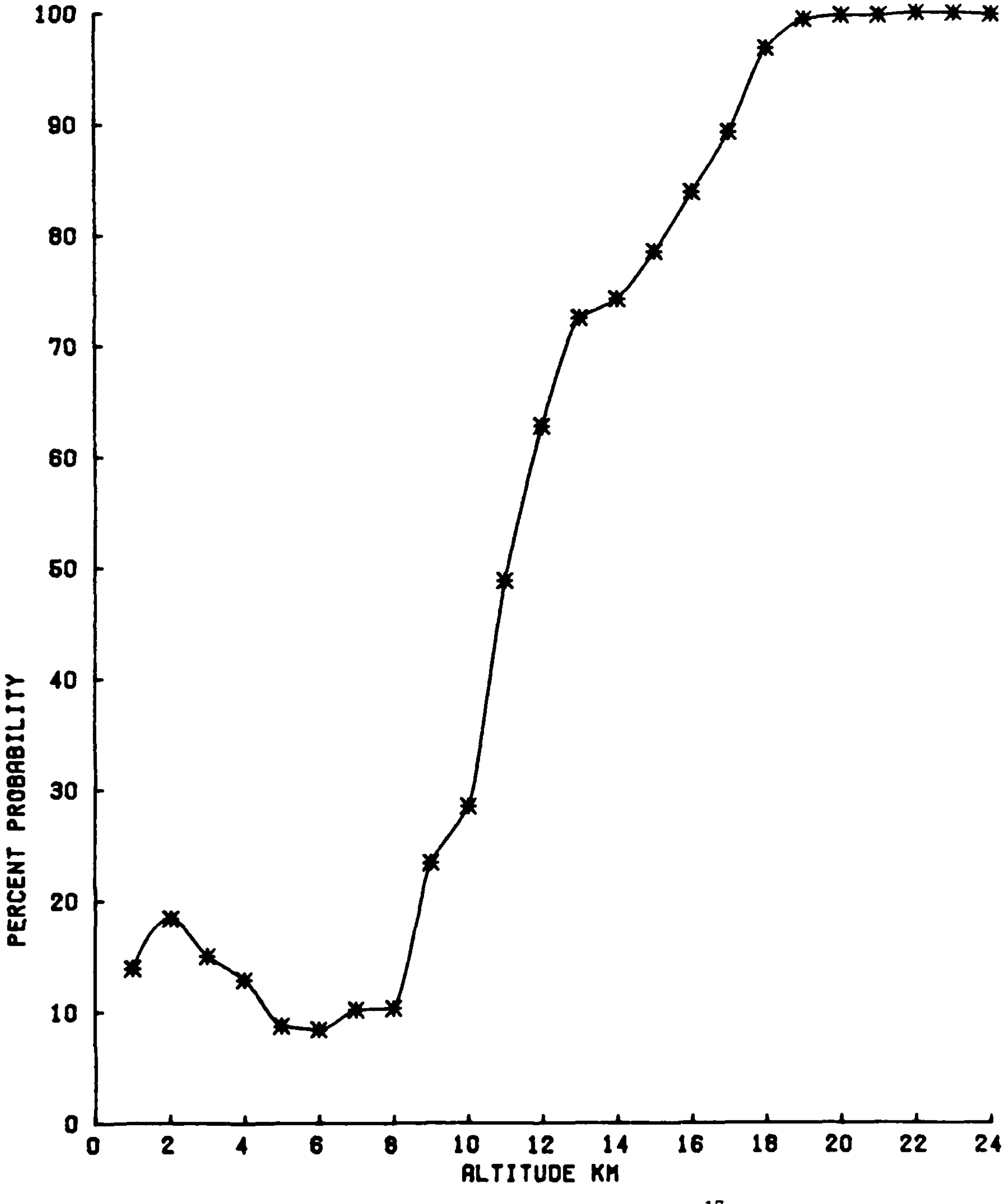

Fig. 3 — Probability of exceeding an ozone concentration of 10×10^{17} molecules per cubic meter

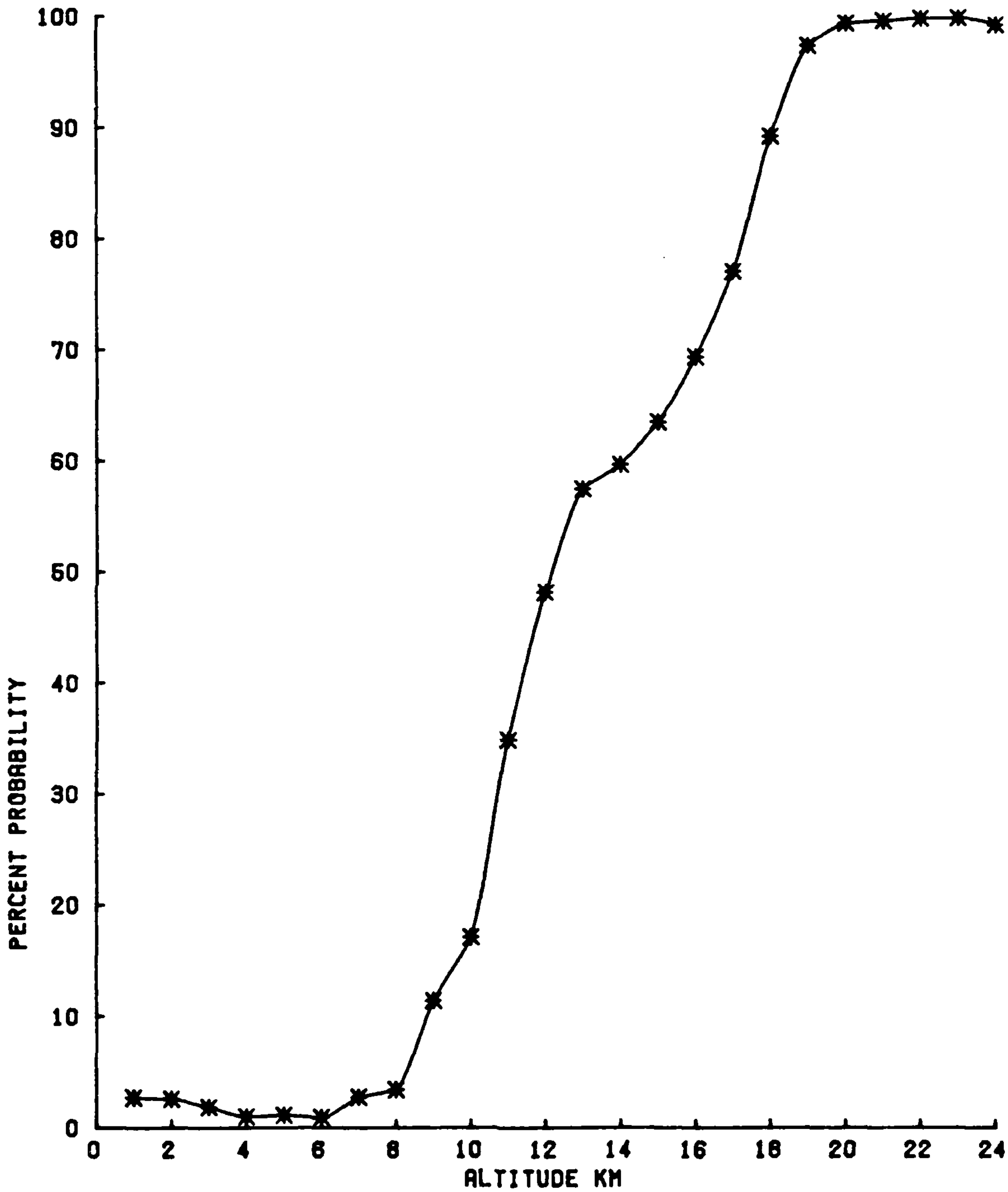

Fig. 4 — Probability of exceeding an ozone concentration of 15×10^{17} molecules per cubic meter

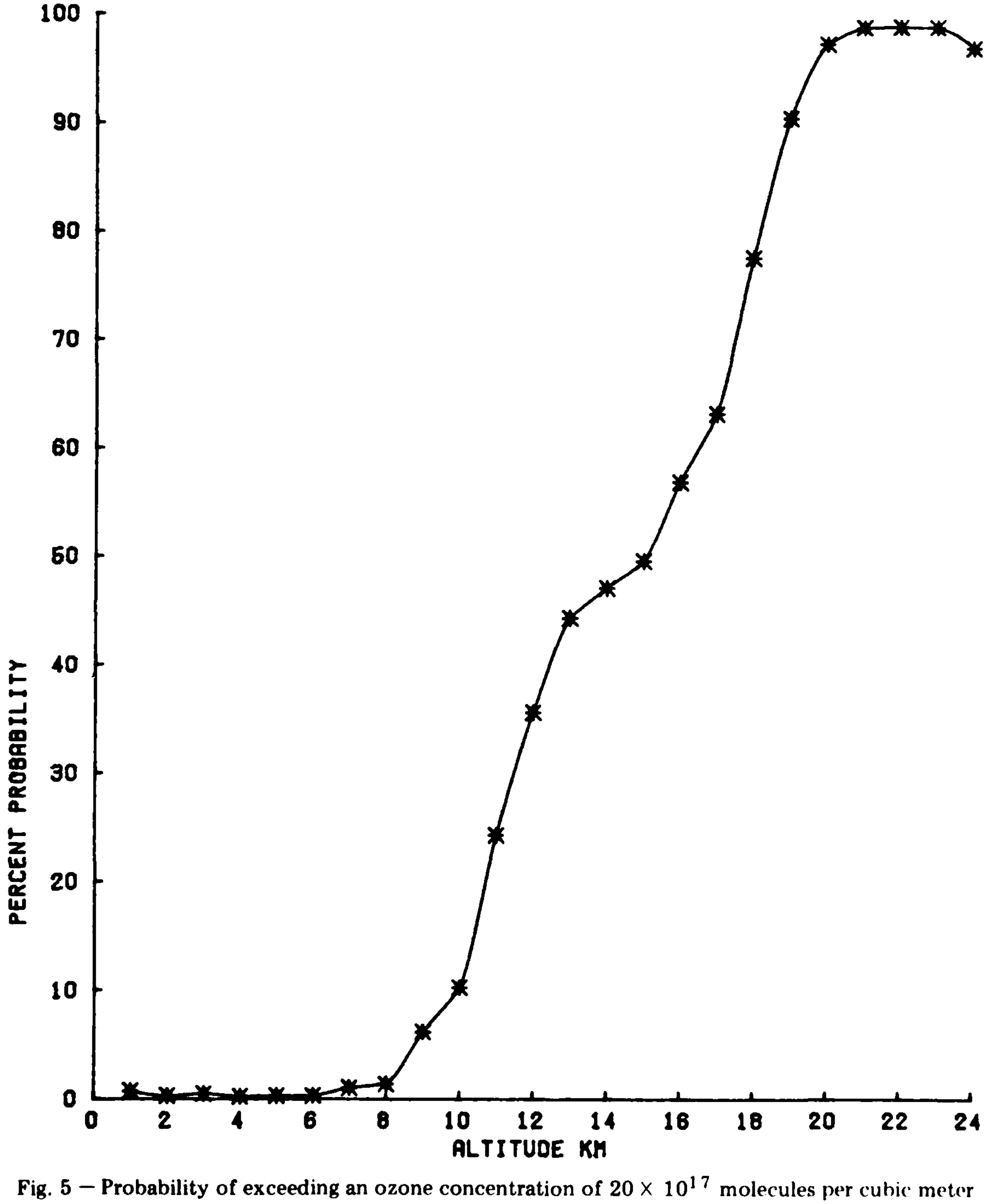

Fig. 5 — Probability of exceeding an ozone concentration of 20×10^{17} molecules per cubic meter

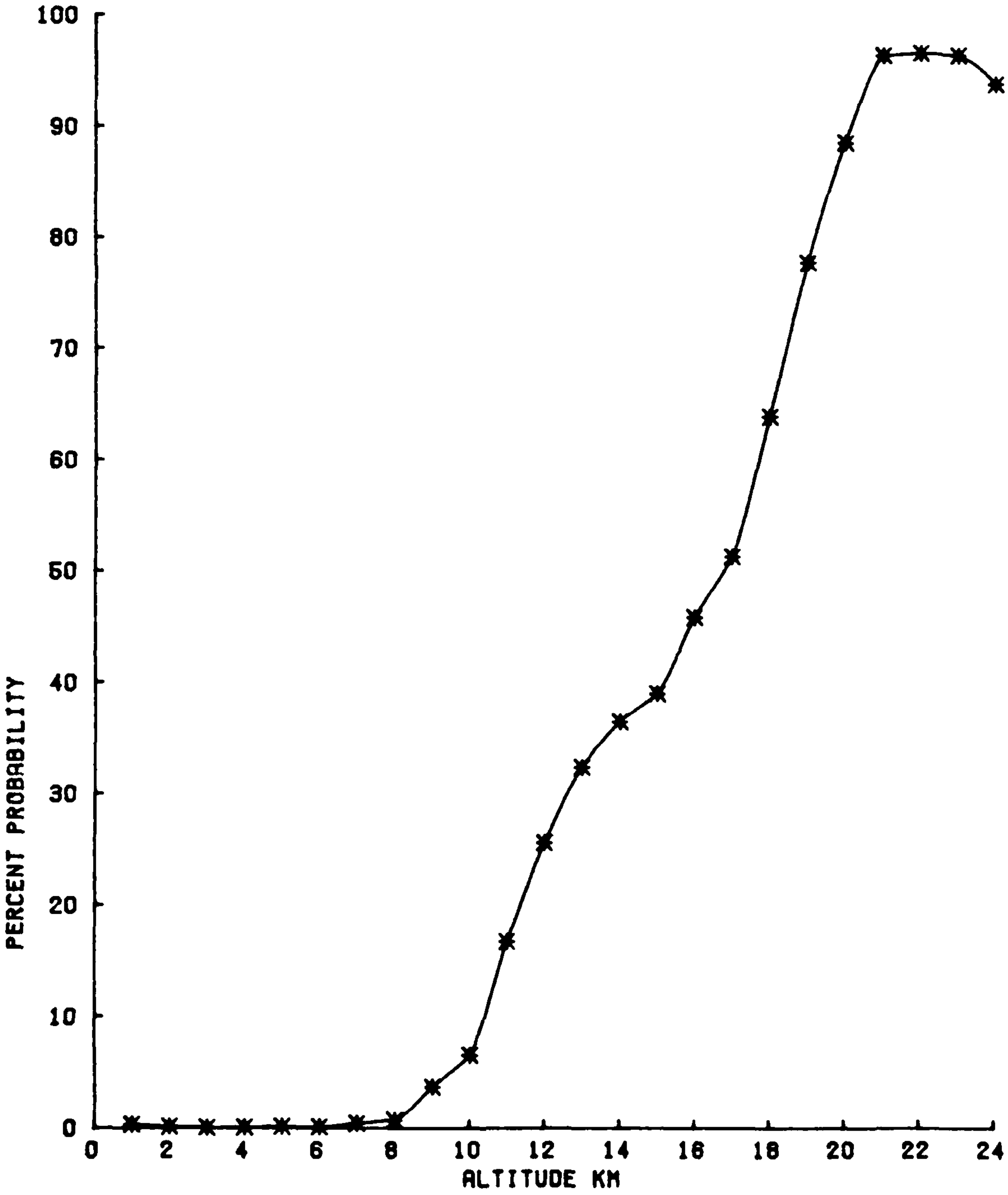

Fig. 6 — Probability of exceeding an ozone concentration of 25×10^{17} molecules per cubic meter

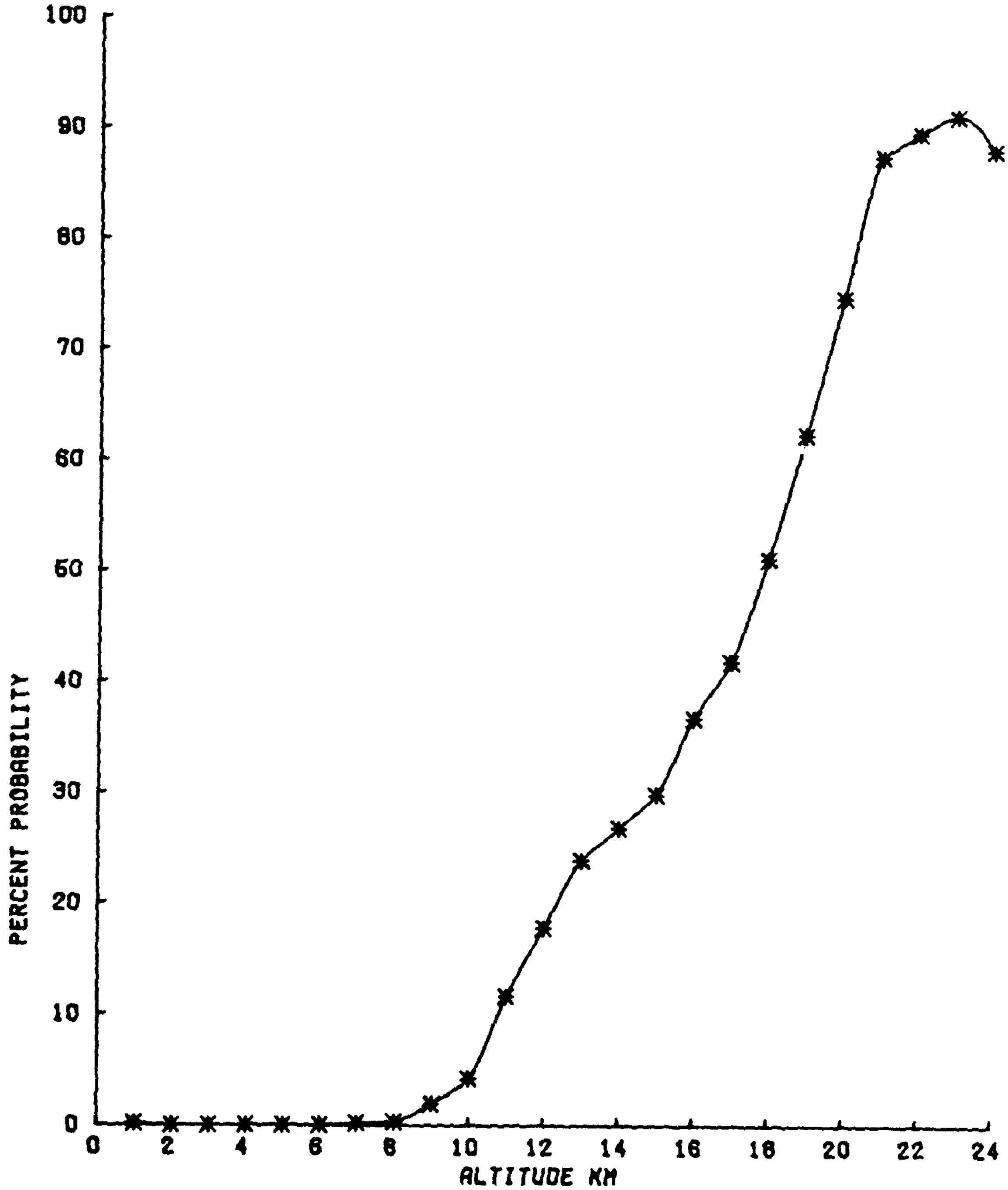

Fig. 7 — Probability of exceeding an ozone concentration of 30×10^{17} molecules per cubic meter

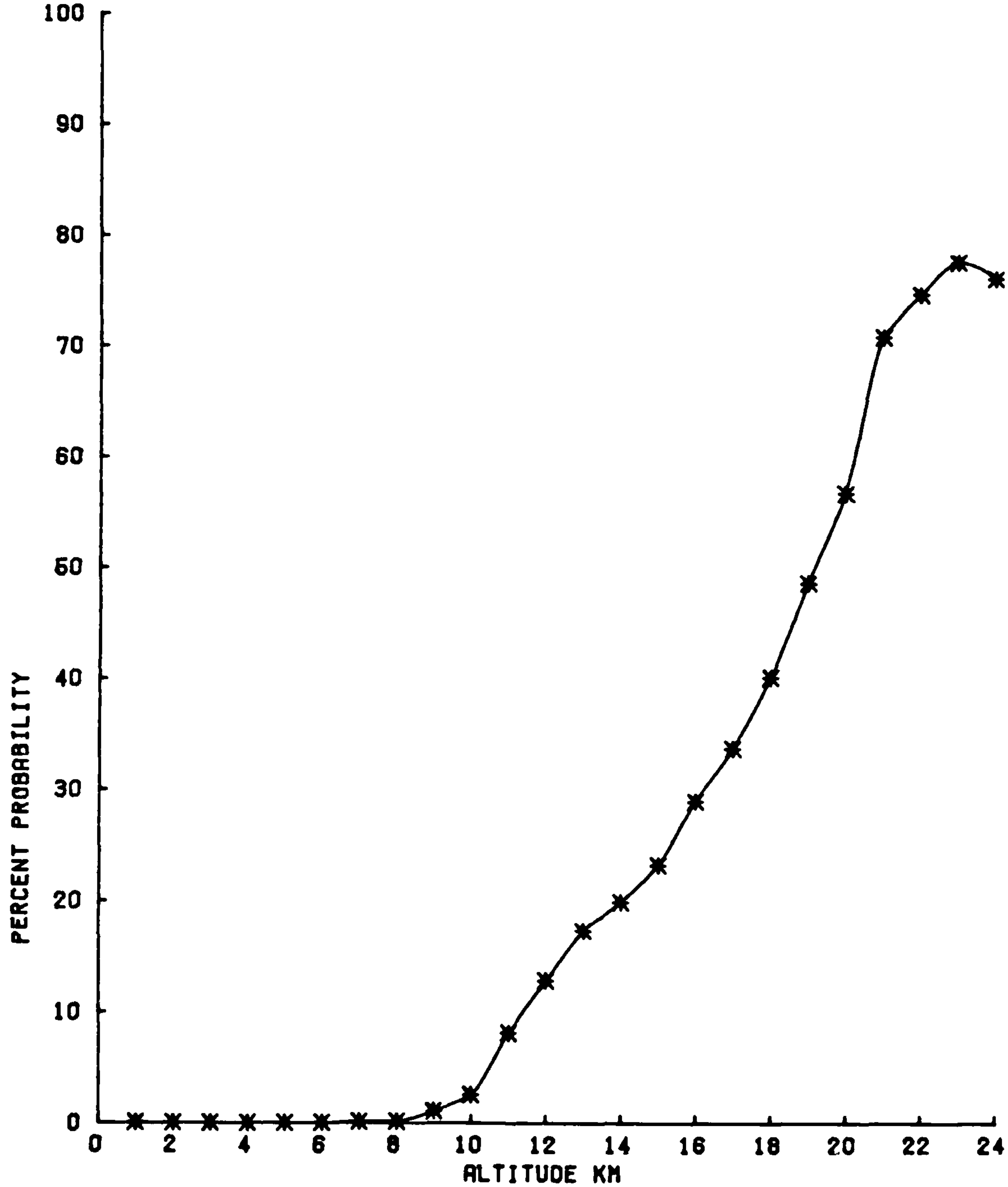

Fig. 8 — Probability of exceeding an ozone concentration of 35×10^{17} molecules per cubic meter

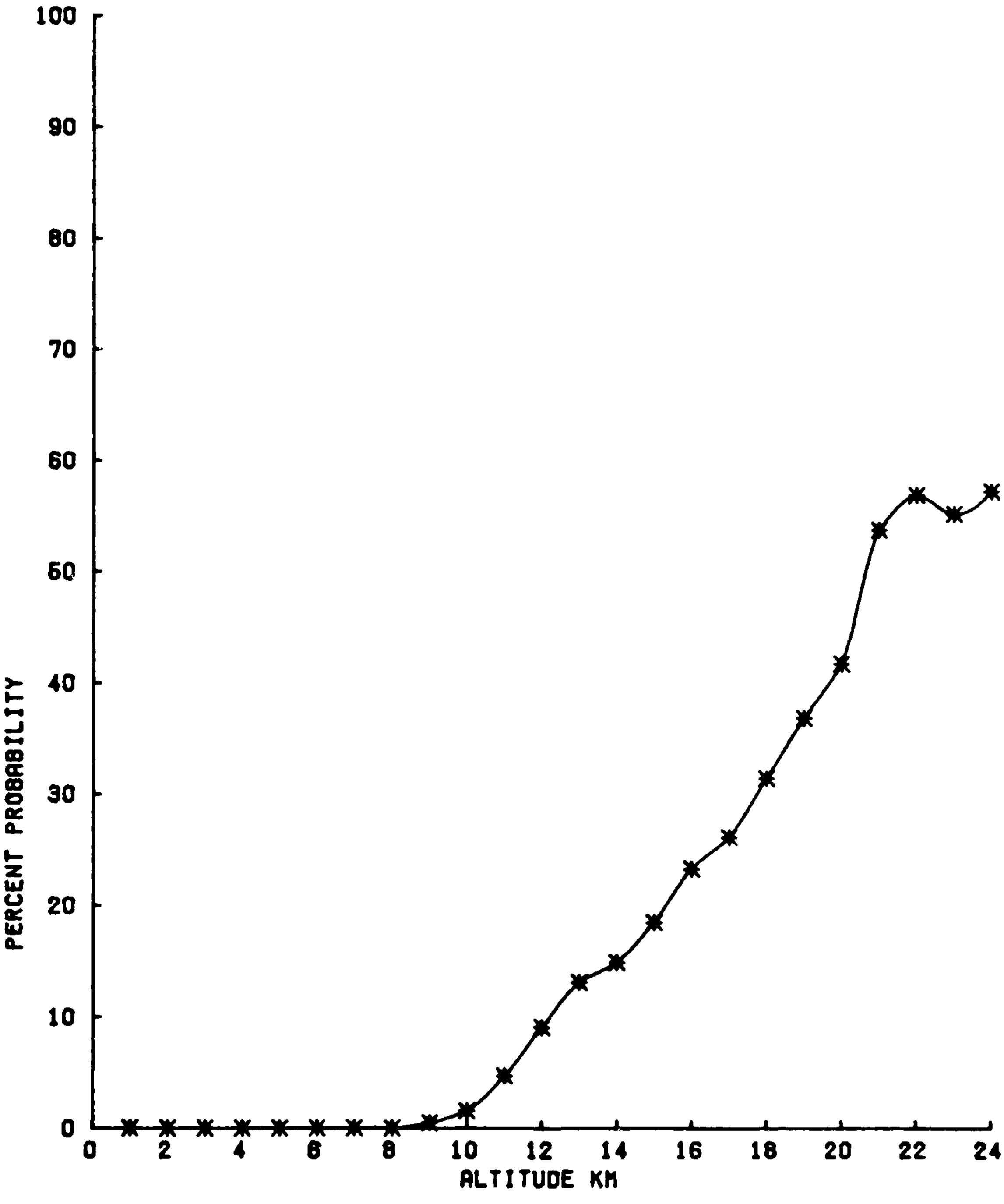

Fig. 9 — Probability of exceeding an ozone concentration of 40×10^{17} molecules per cubic meter

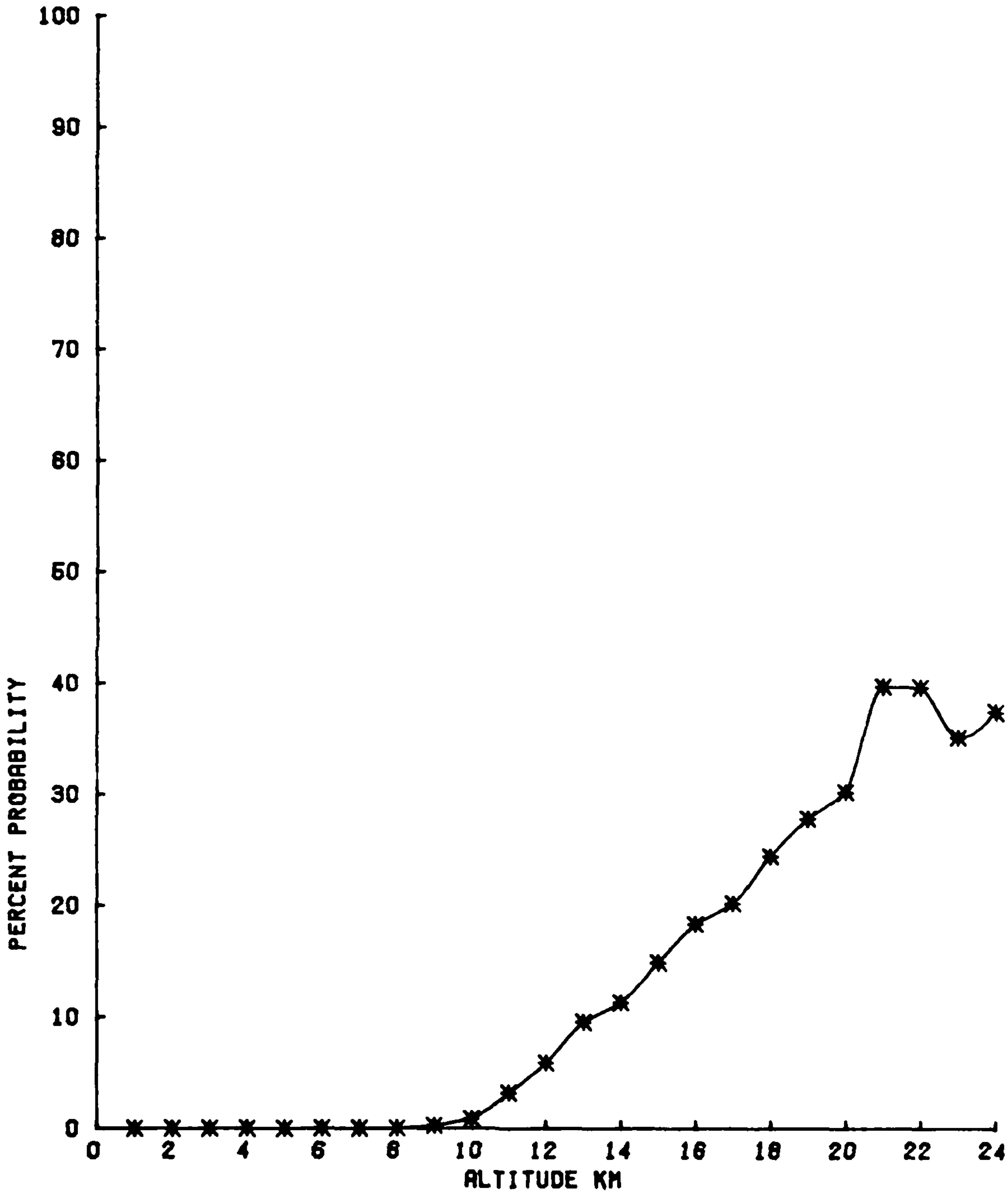

Fig. 10 — Probability of exceeding an ozone concentration of 45×10^{17} molecules per cubic meter

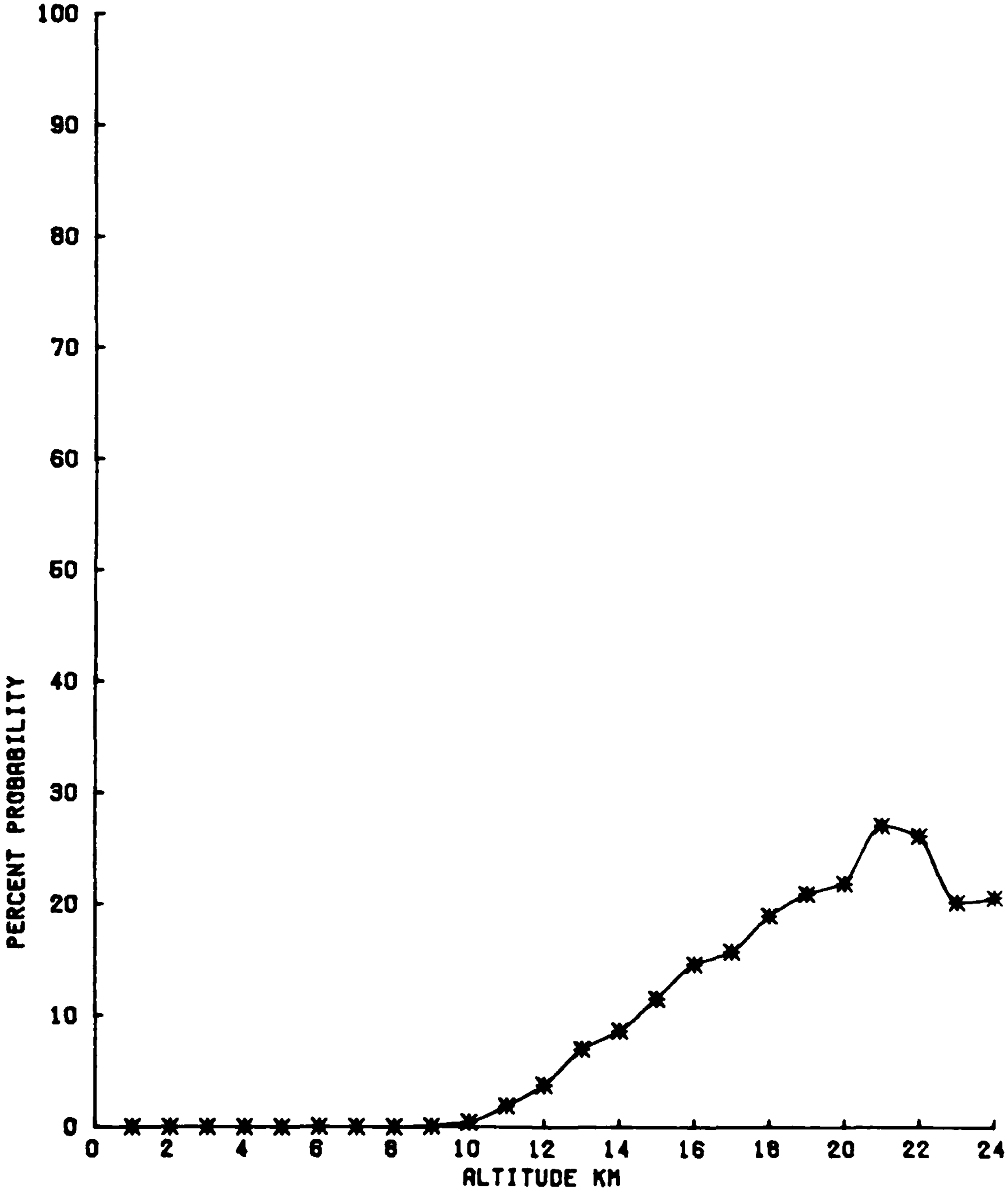

Fig. 11 — Probability of exceeding an ozone concentration of 50×10^{17} molecules per cubic meter

APPENDIX A

Format of the Ozonesonde Data Base Magnetic Tape

The ozonesonde data is stored on magnetic tape in 80 column punched card integer format. The format is as follows:

<u>Card 1</u>

Columns	
1 - 3	Used by data center
4 - 5	Card number (01, 02, ... 21)
6 - 11	YYMMJJ, day, month, year
12 - 13	GG, nearest hour in Greenwich Mean Time
14 - 16	Used by data center
17 - 21	$\lambda S\Omega\Omega\Omega$, total amount of ozone
22 - 24	$\Omega_p(\Omega\Omega\Omega)_p$, total amount of ozone above or below lowest pressure level (LPL). Optical sondes $(\Omega\Omega\Omega)_p$ is the total amount above LPL. For chemical sondes, $(\Omega\Omega\Omega)_p$ is the total amount below LPL.
25 - 26	X, instrument type code: 1 = Brewer, 10 = Mast, 12 = Paetzold, 13 = Regener, 15 = Vassy, 16 = Carbon-Iodine, 99 = Other
27 - 31	Correction factor
32 - 80	Significant comments

Cards 2 through 21

Columns

1 - 16	Complete as for card 1
17 - 20	PPPP, pressure level in millibars
21 - 23	P_3 ($P_3P_3P_3$), ozone partial pressure in micro-millibars
24 - 26	TTT, air temperature in degrees Celsius
27 - 29	ddd, wind direction in degrees
30 - 32	fff, wind speed in meters per second
33 - 48	Complete as for 17 - 32
49 - 64	Complete as for 17 - 32
65 - 80	Complete as for 17 - 32

APPENDIX B

Ozone Concentration Histograms for Altitudes up to 25 Kilometers

This appendix contains histograms showing the frequency of occurrence of ozone concentrations up to and including 49×10^{17} molecules per cubic meter. Data may exist beyond this limit. See Table 5 for concentrations up to 100×10^{17} molecules per cubic meter.

<u>Note</u> 10**17 is computer notation for 10^{17}.

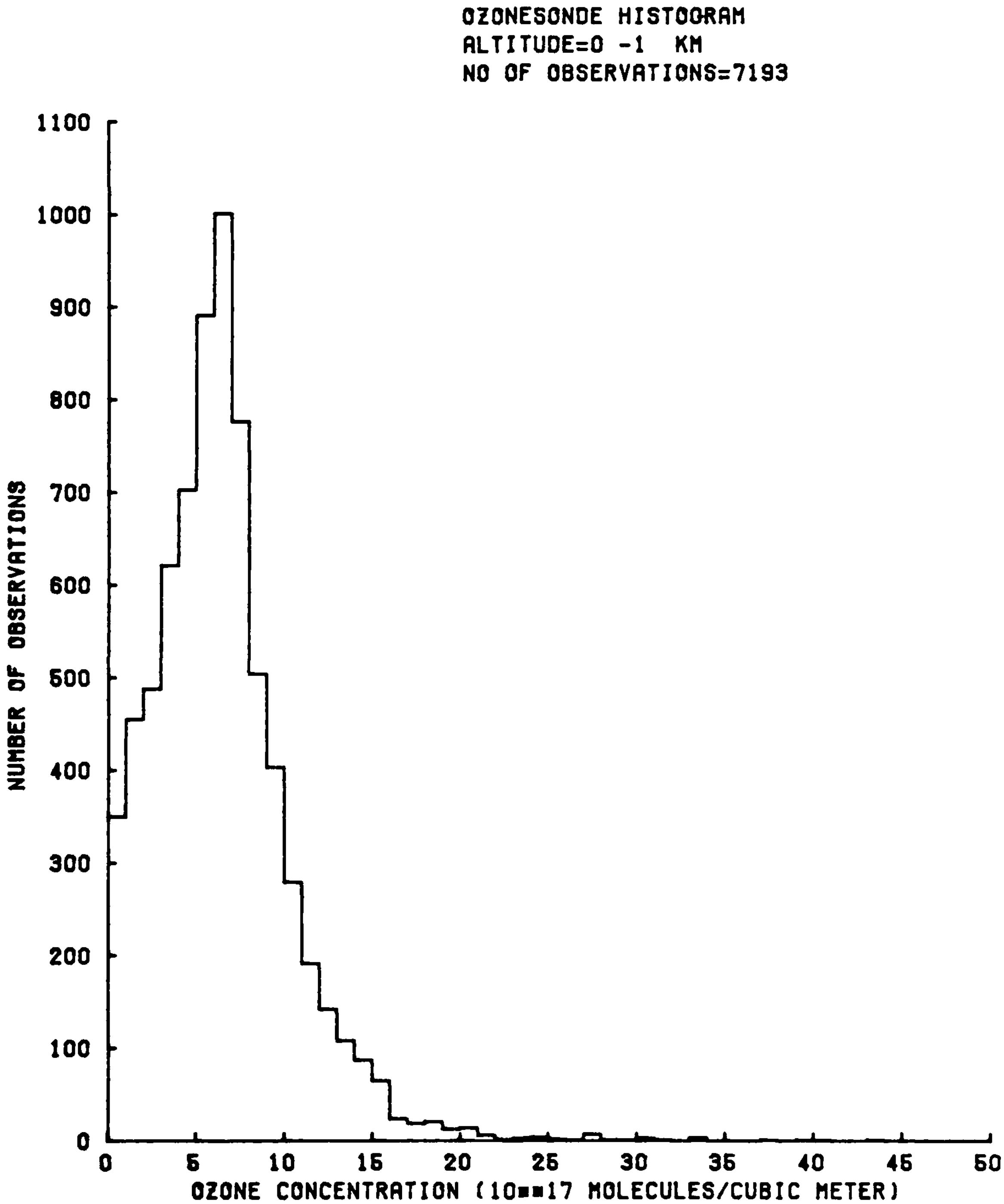

Fig. B1 — Ozone concentration histogram for altitudes between 0 and 1 kilometer

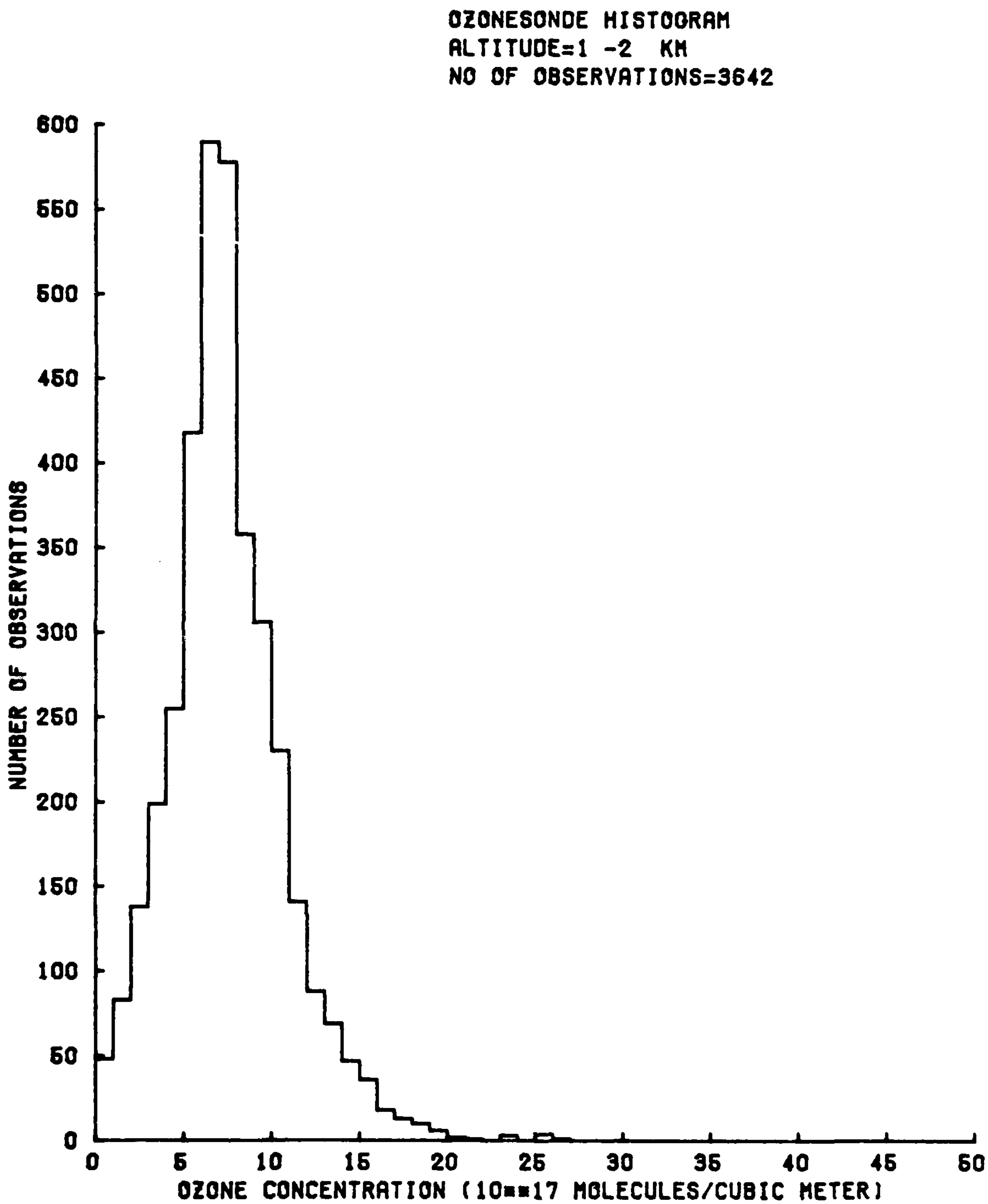

Fig. B2 — Ozone concentration histogram for altitudes between 1 and 2 kilometers

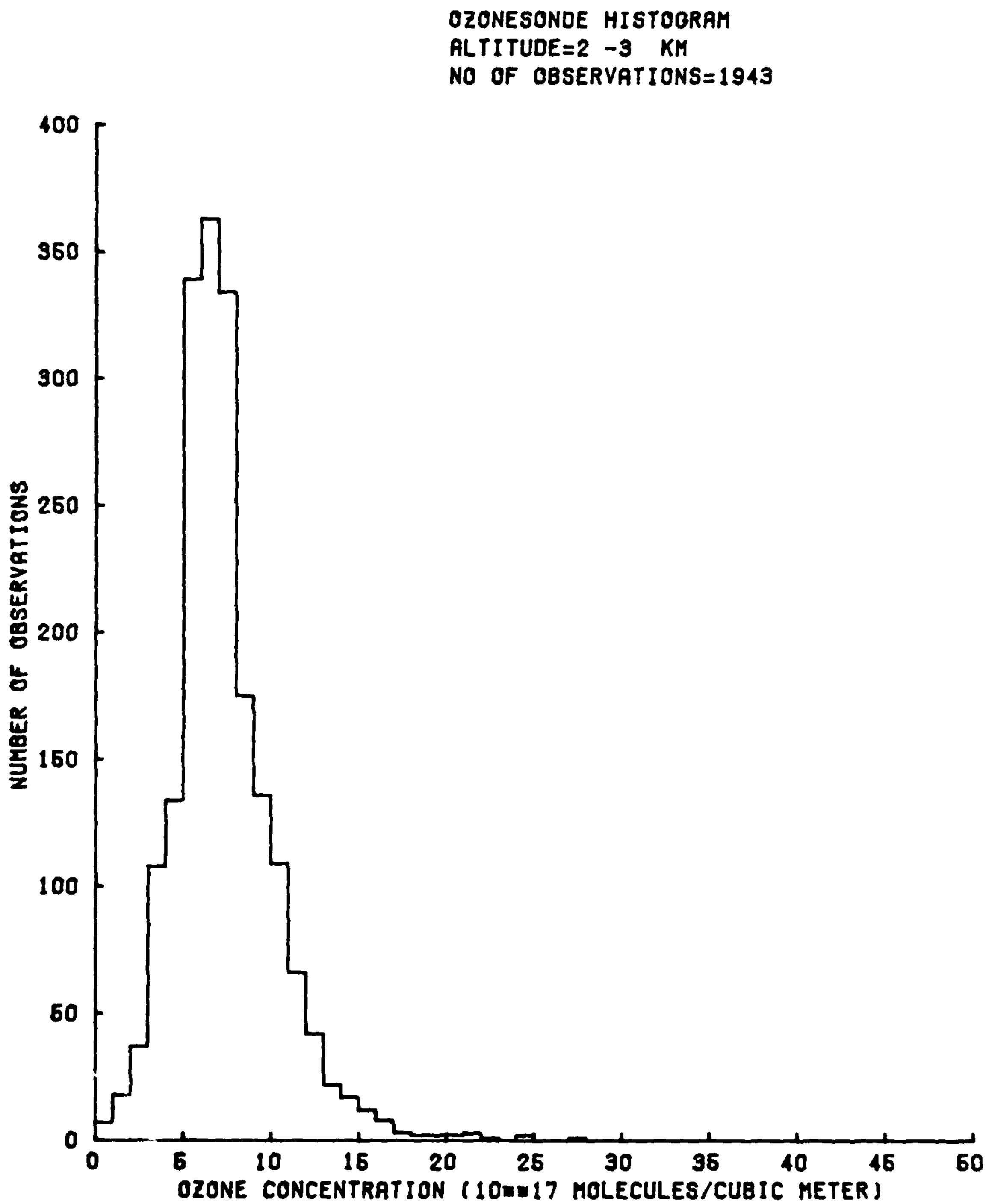

Fig. B3 — Ozone concentration histogram for altitudes between 2 and 3 kilometers

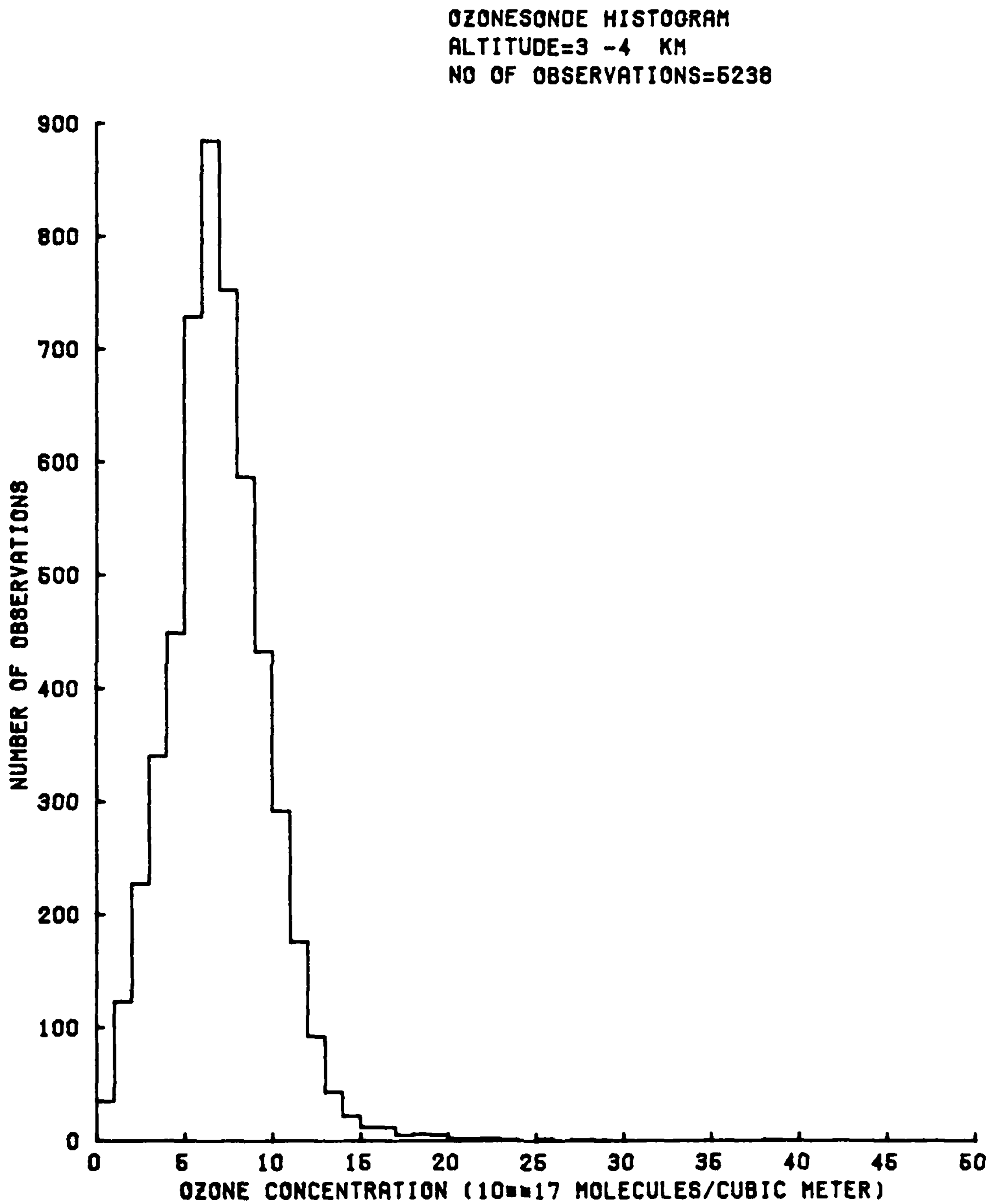

Fig. B4 — Ozone concentration histogram for altitudes between 3 and 4 kilometers

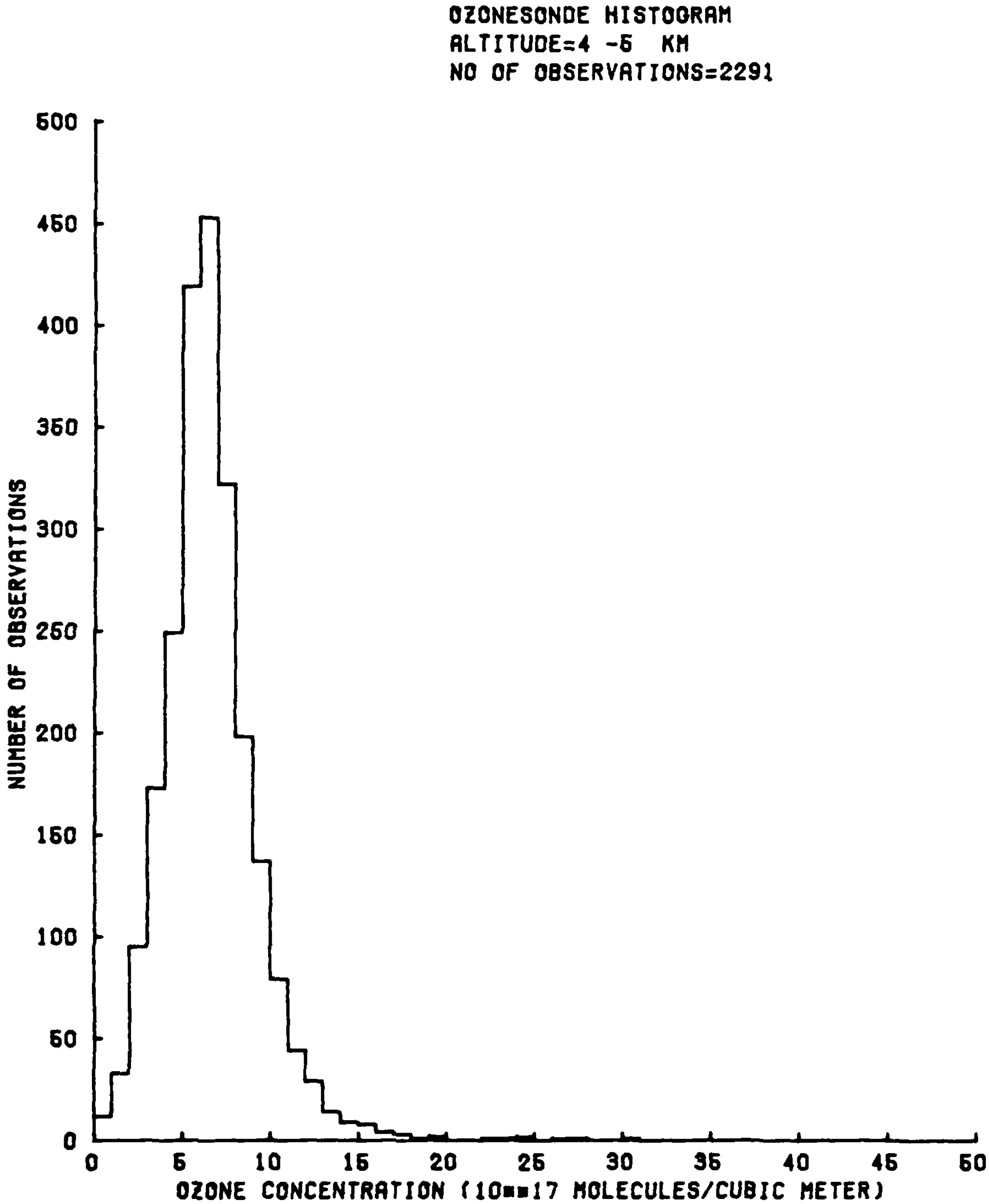

Fig. B5 — Ozone concentration histogram for altitudes between 4 and 5 kilometers

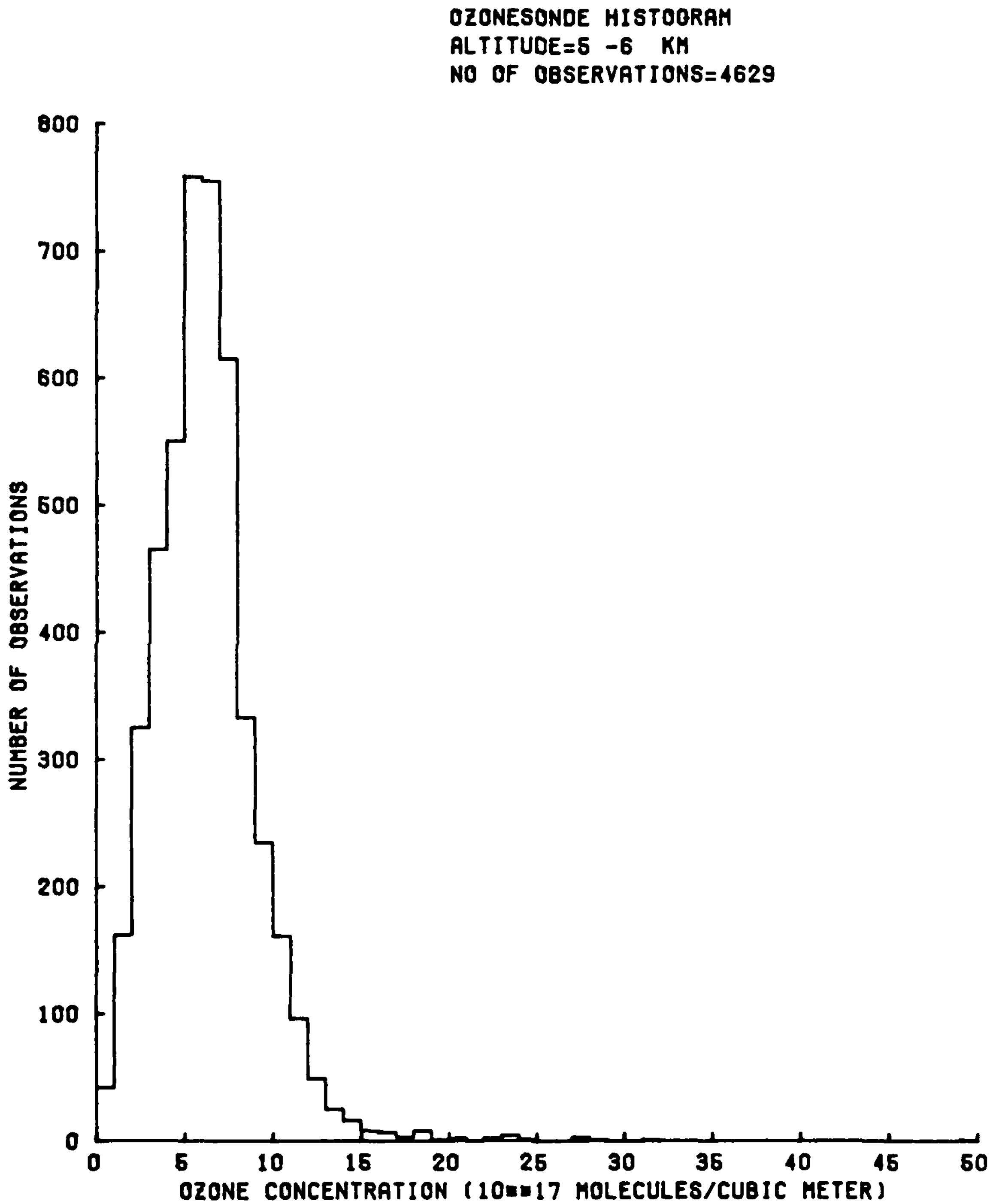

Fig. B6 — Ozone concentration histogram for altitudes between 5 and 6 kilometers

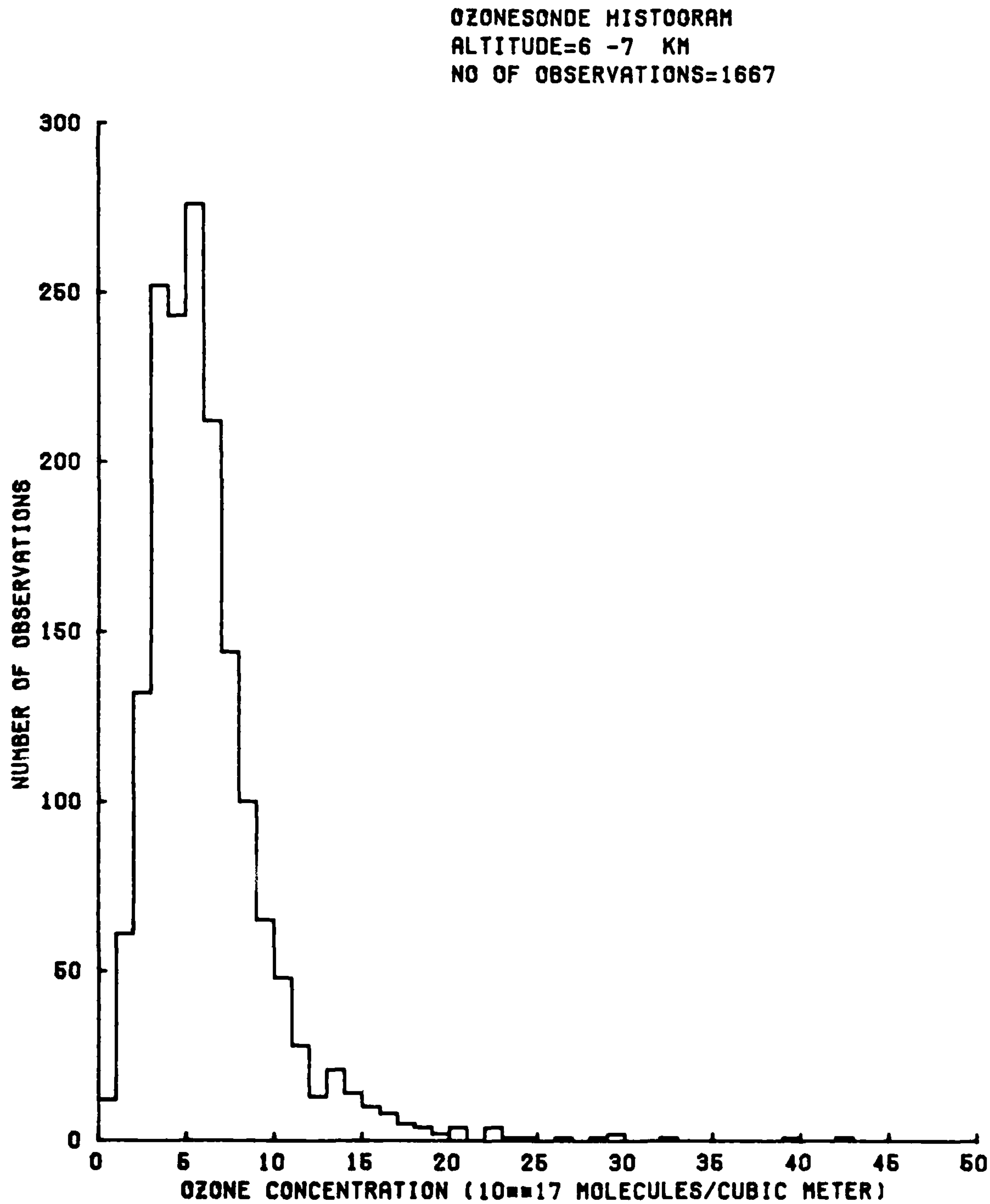

Fig. B7 — Ozone concentration histogram for altitudes between 6 and 7 kilometers

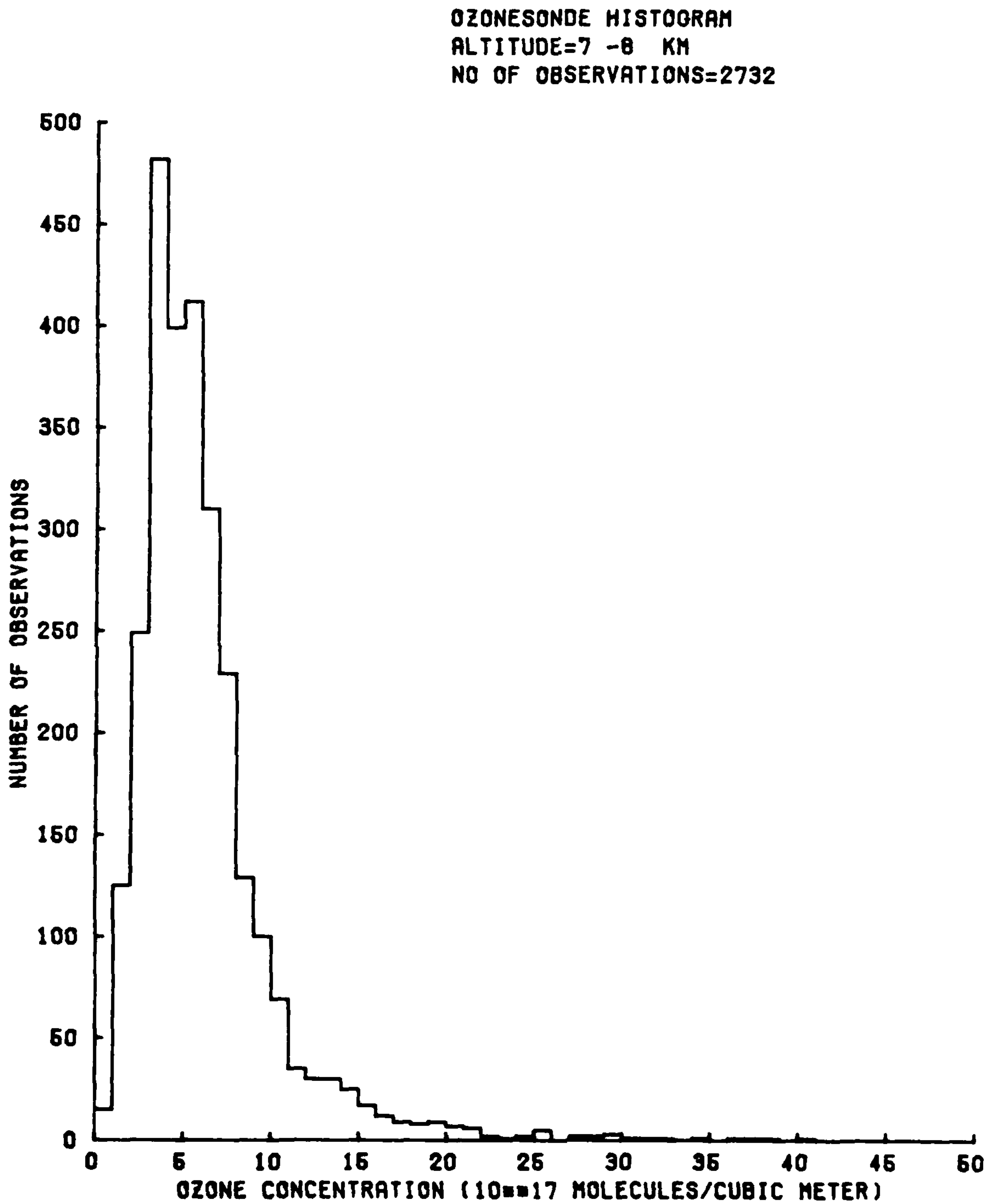

Fig. B8 — Ozone concentration histogram for altitudes between 7 and 8 kilometers

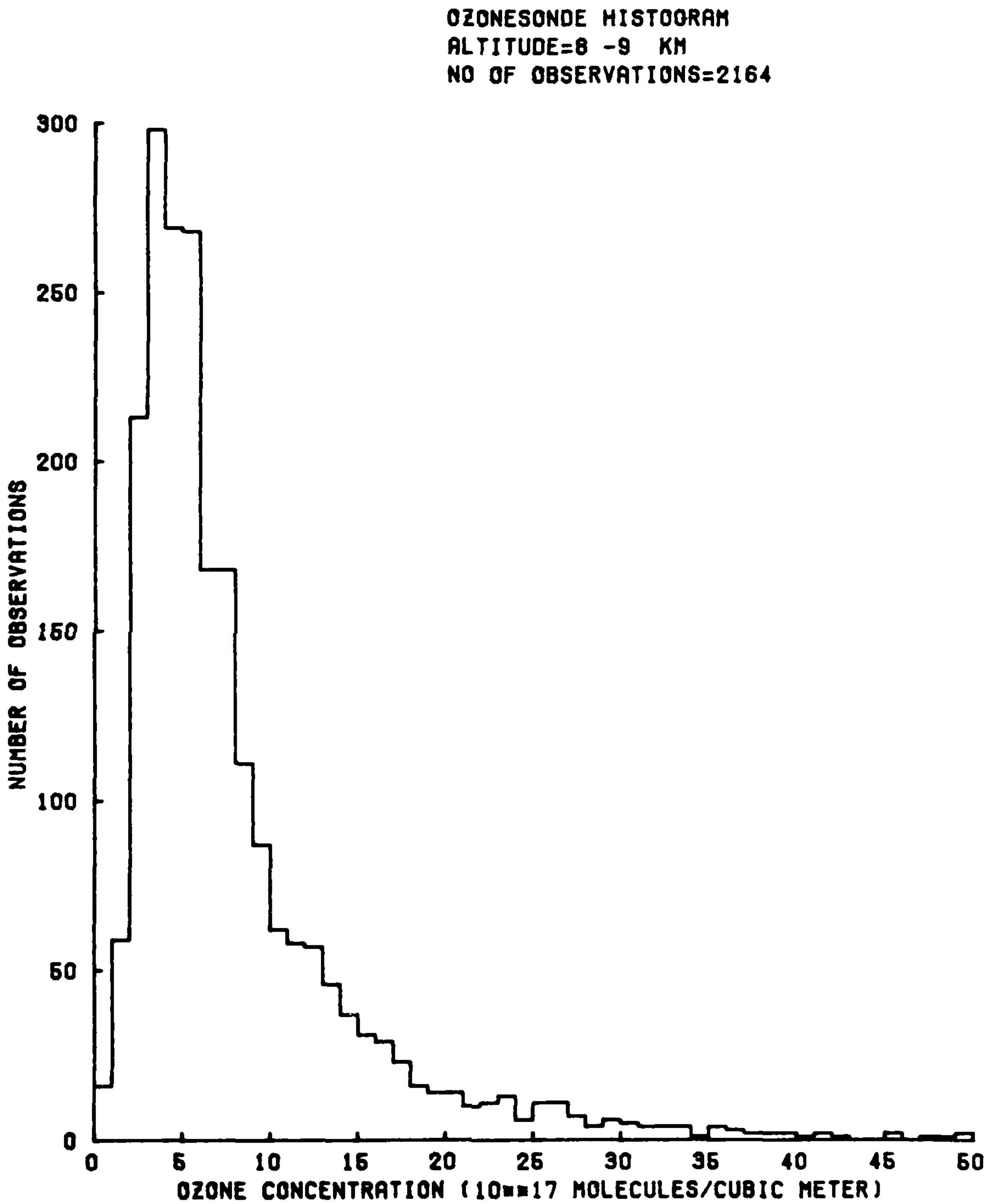

Fig. B9 — Ozone concentration histogram for altitudes between 8 and 9 kilometers

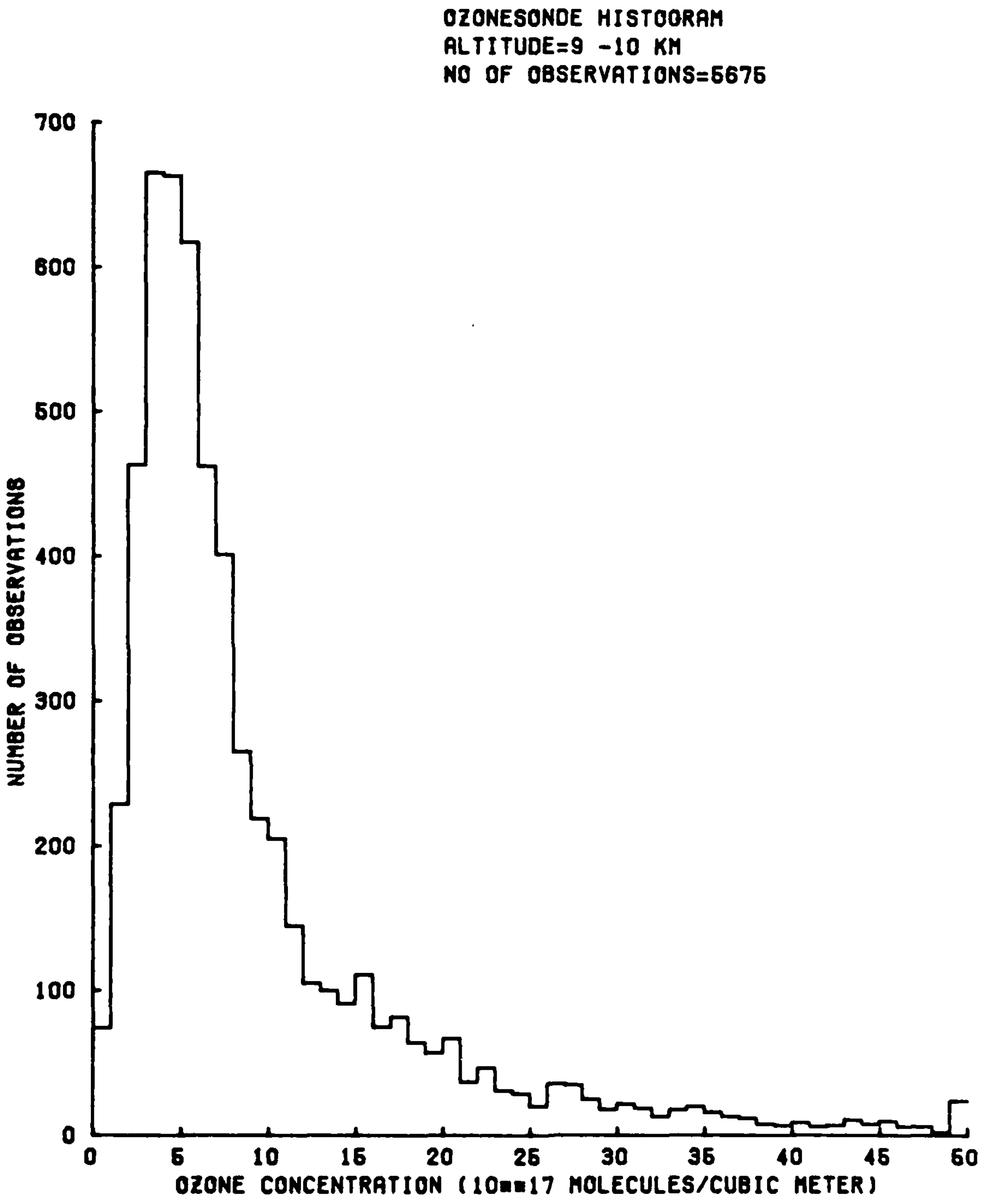

Fig. B10 — Ozone concentration histogram for altitudes between 9 and 10 kilometers

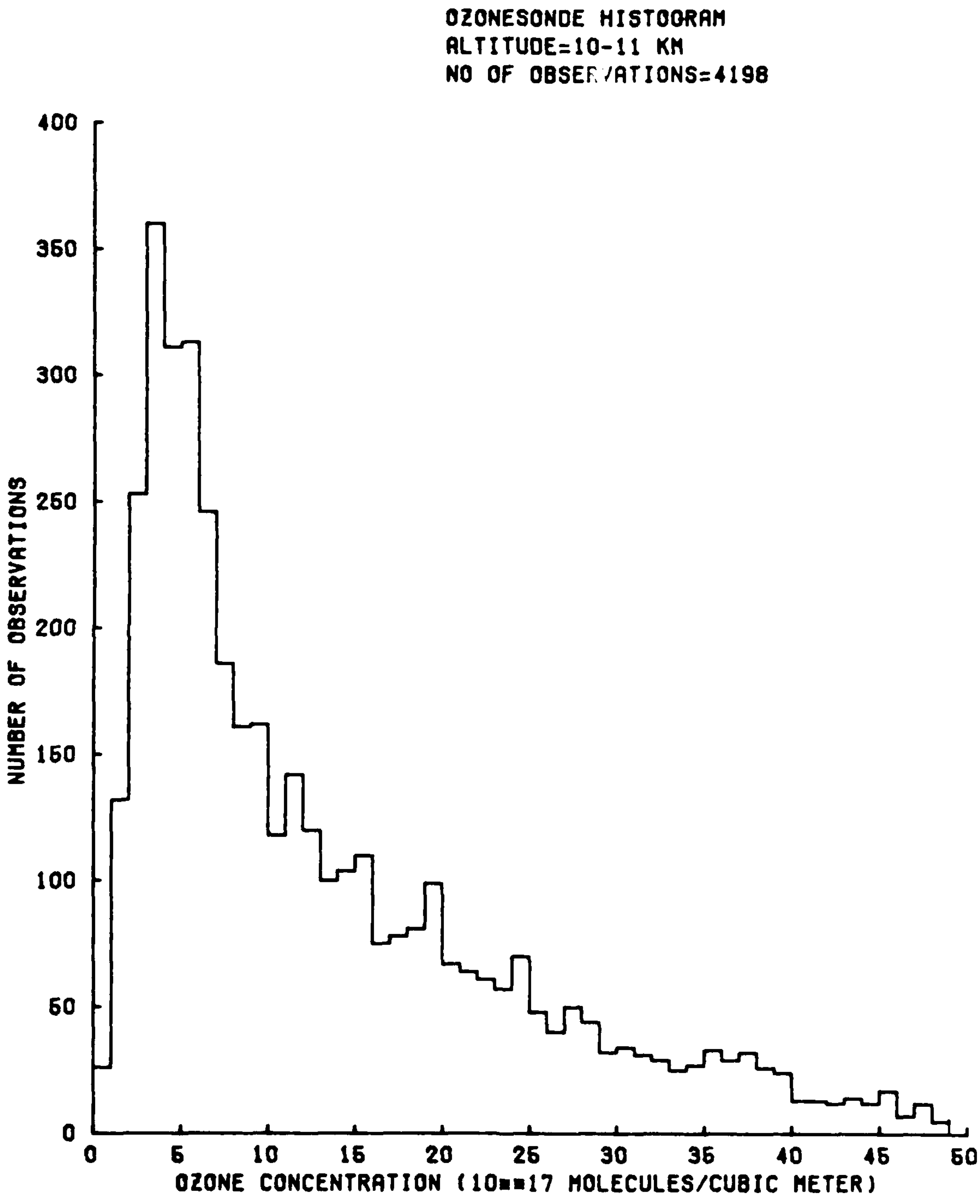

Fig. B11 — Ozone concentration histogram for altitudes between 10 and 11 kilometers

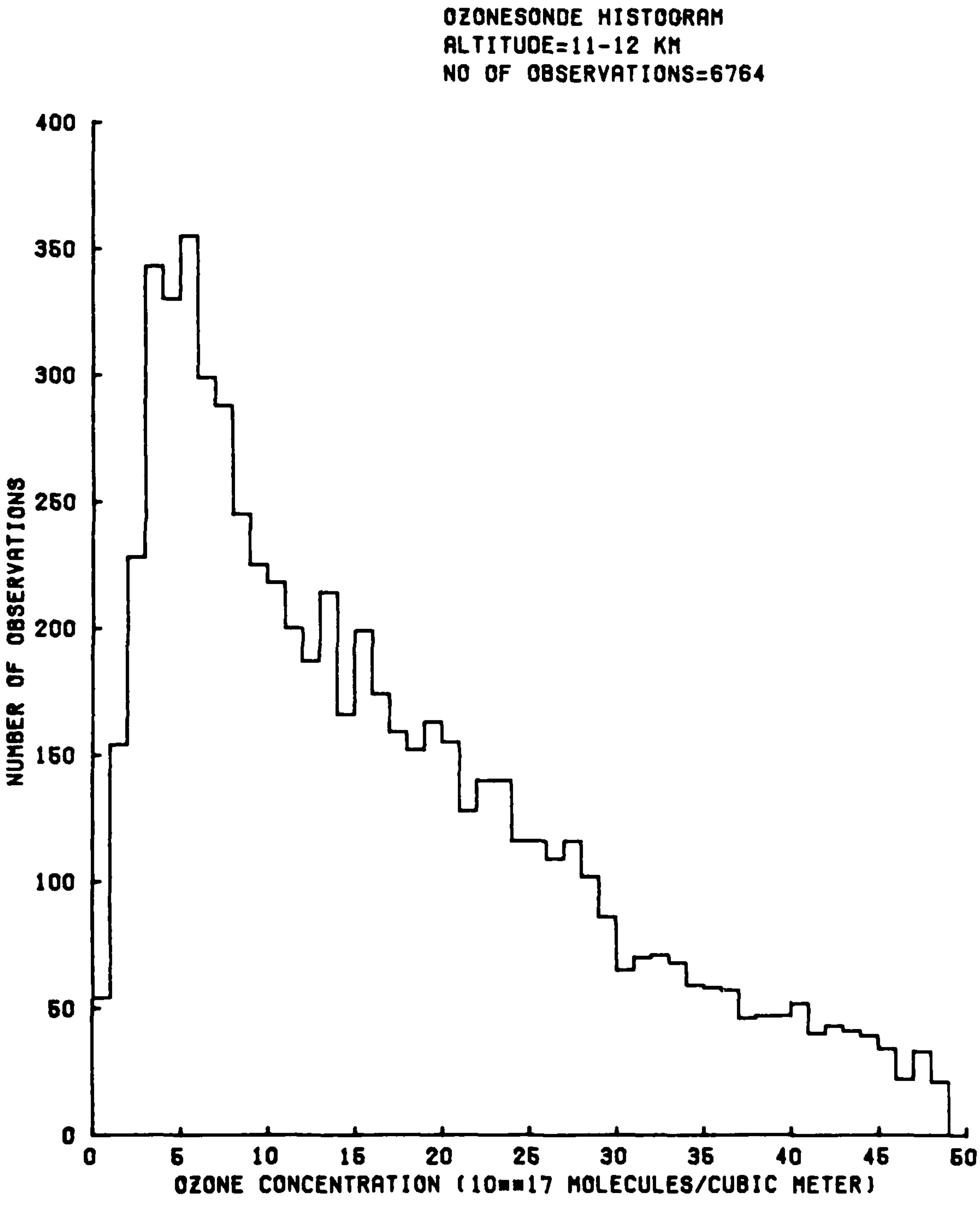

Fig. B12 — Ozone concentration histogram for altitudes between 11 and 12 kilometers

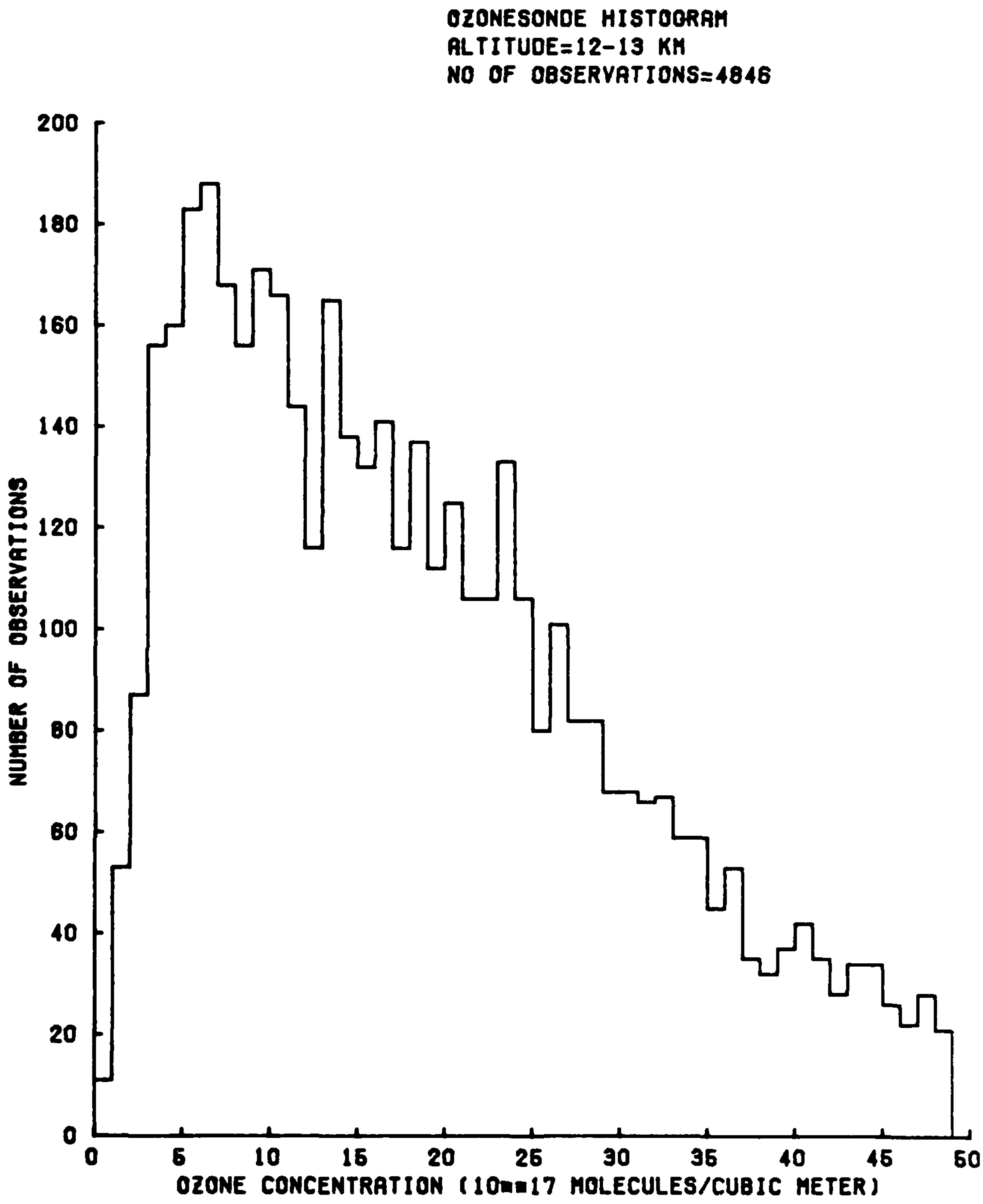

Fig. B13 — Ozone concentration histogram for altitudes between 12 and 13 kilometers

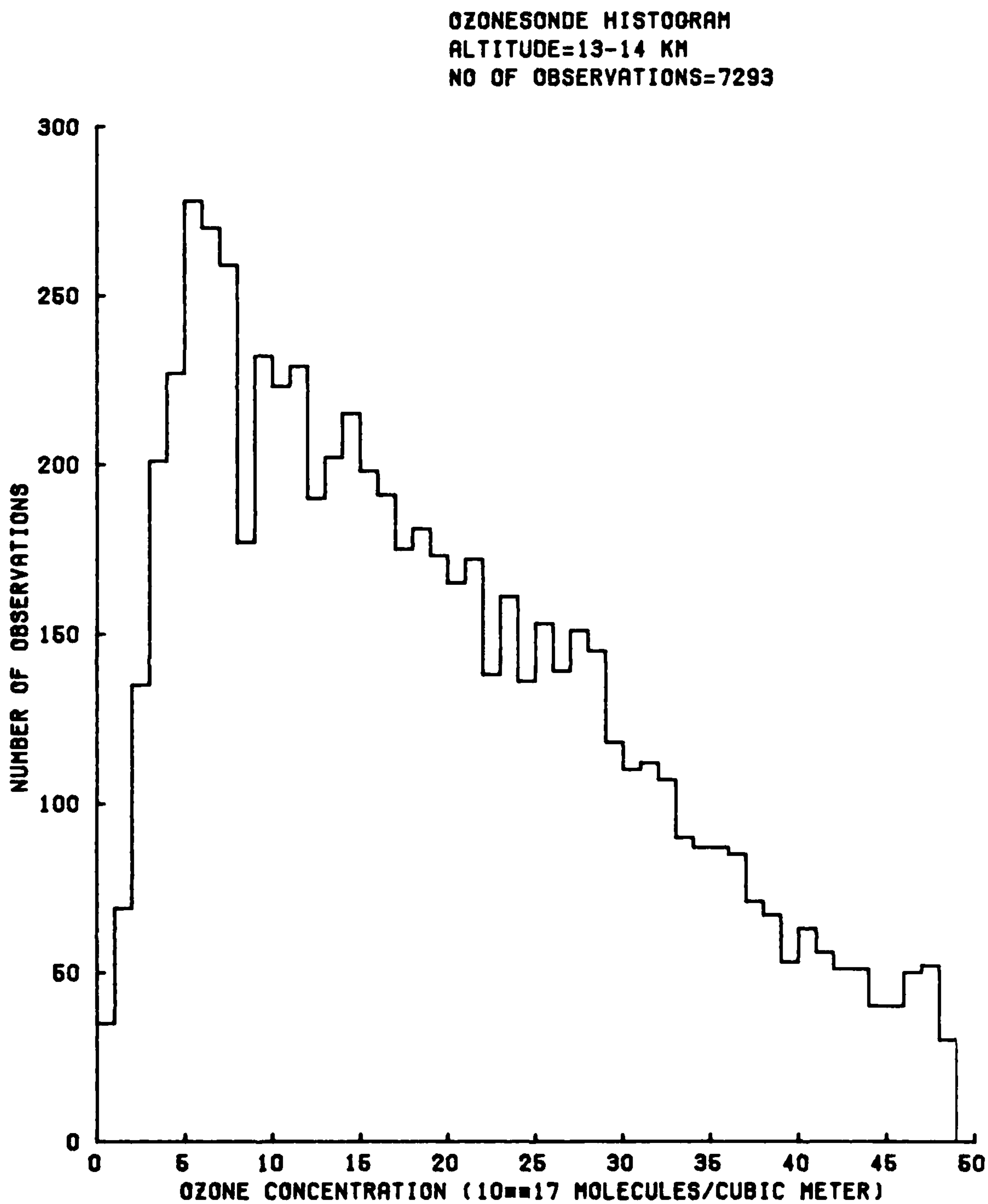

Fig. B14 — Ozone concentration histogram for altitudes between 13 and 14 kilometers

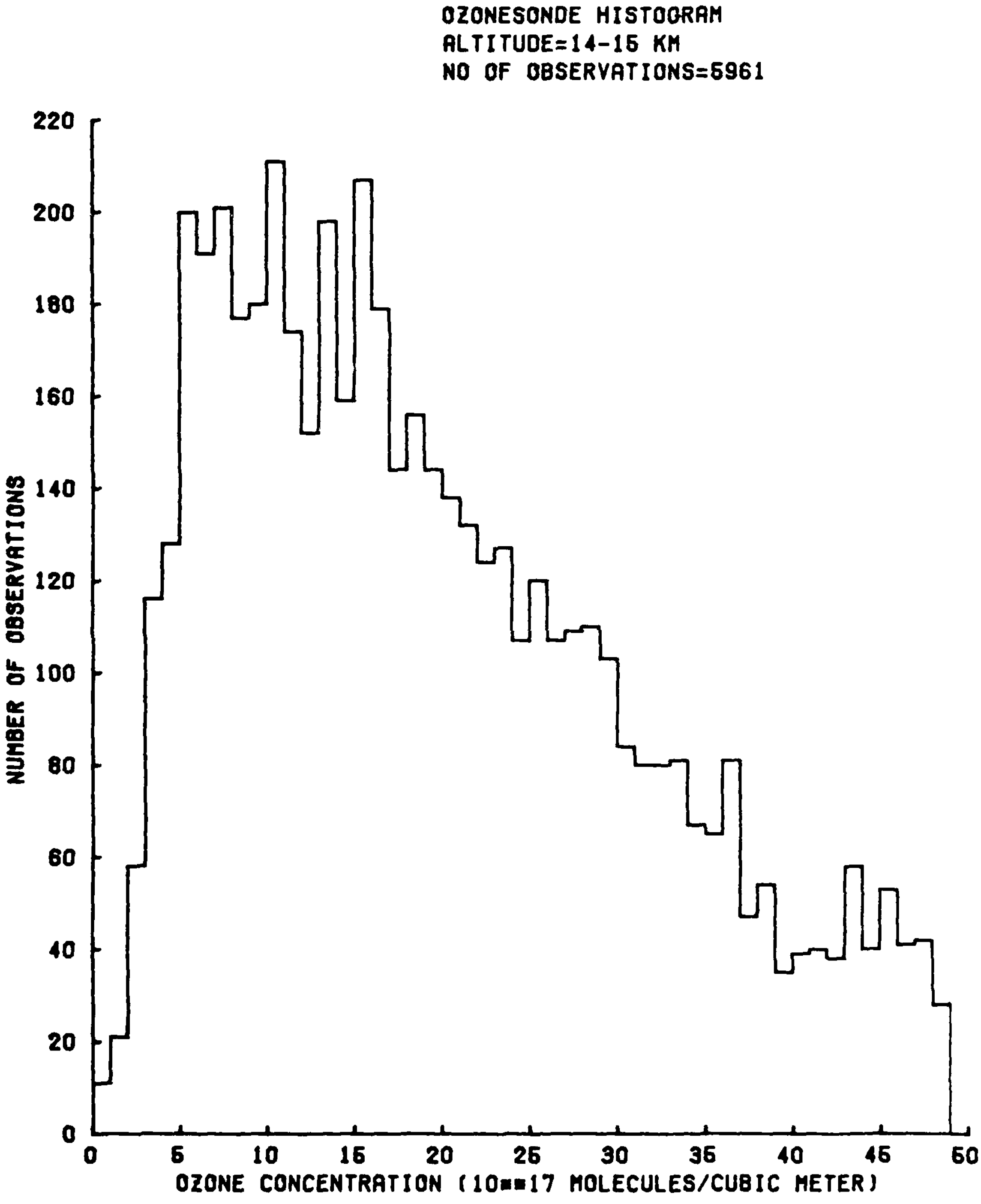

Fig. B15 — Ozone concentration histogram for altitudes between 14 and 15 kilometers

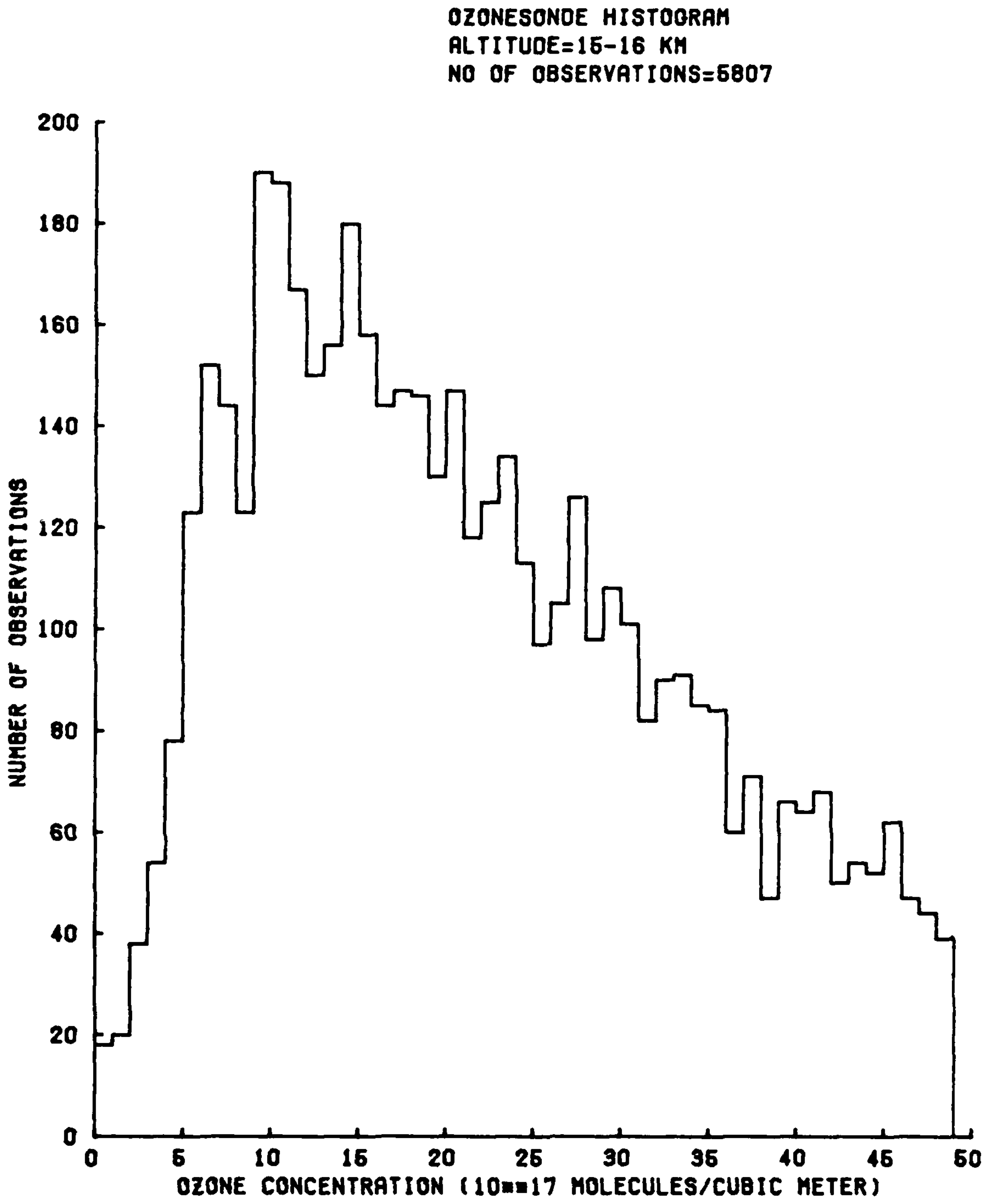

Fig. B16 — Ozone concentration histogram for altitudes between 15 and 16 kilometers

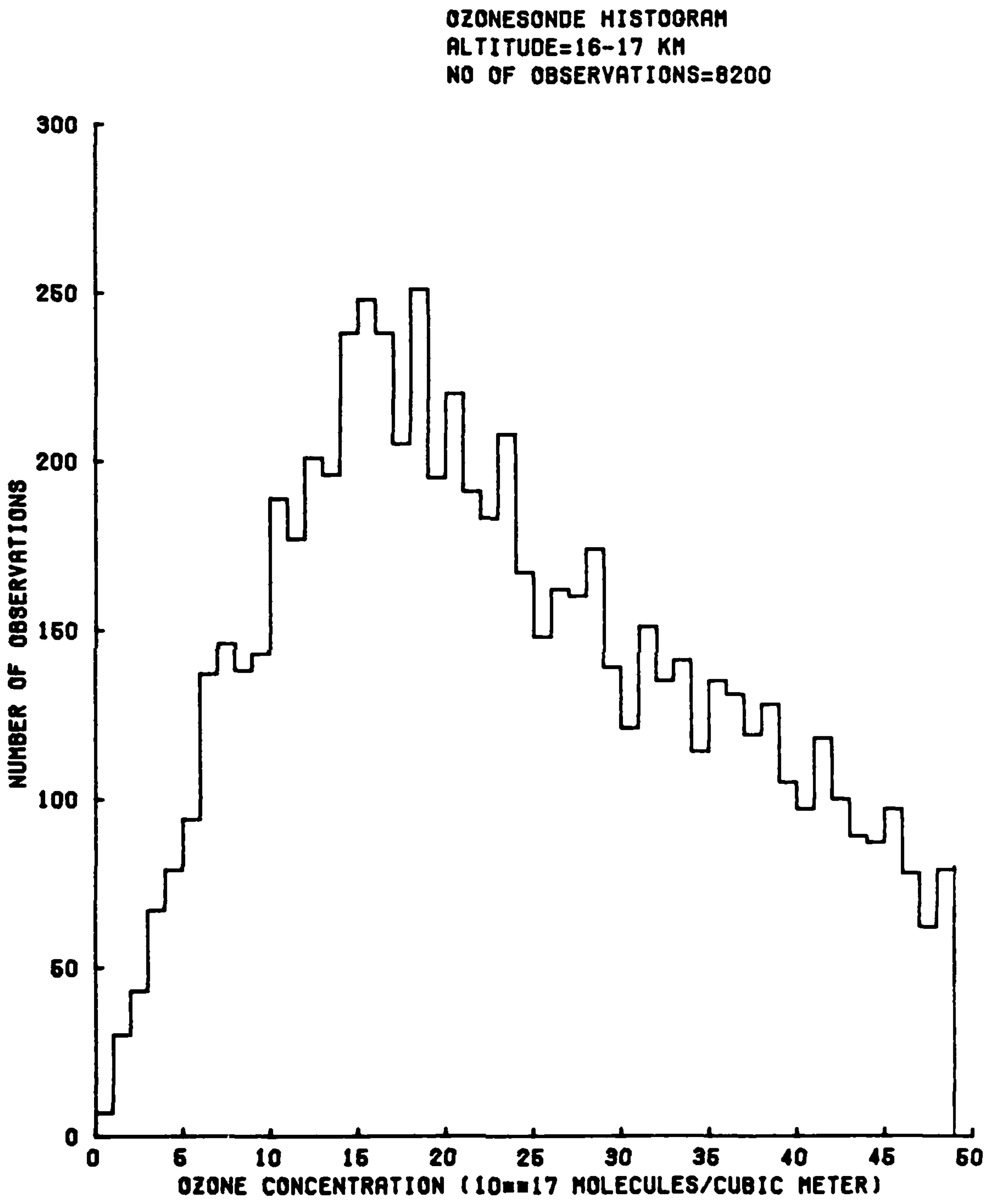

Fig. B17 — Ozone concentration histogram for altitudes between 16 and 17 kilometers

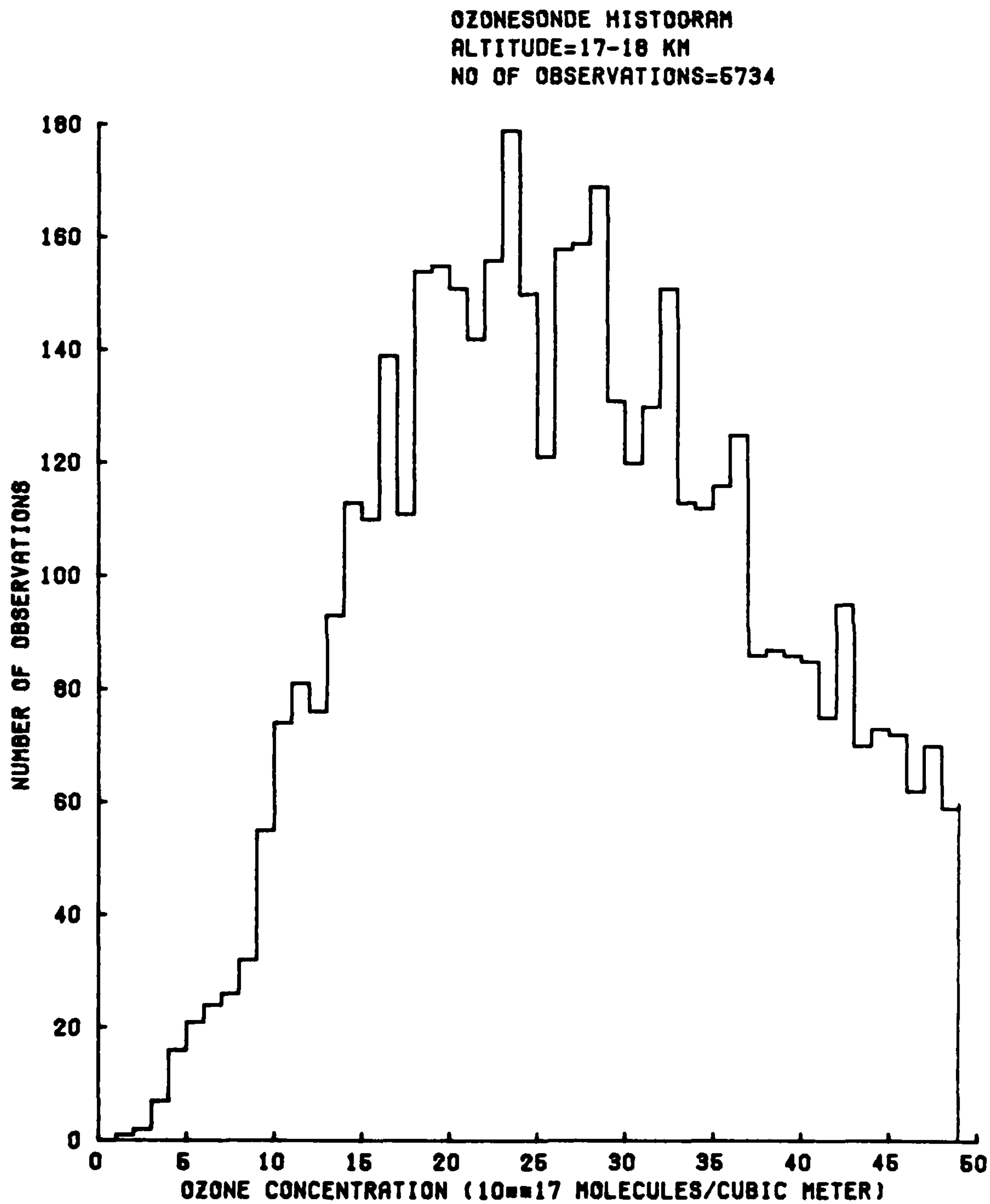

Fig. B18 — Ozone concentration histogram for altitudes between 17 and 18 kilometers

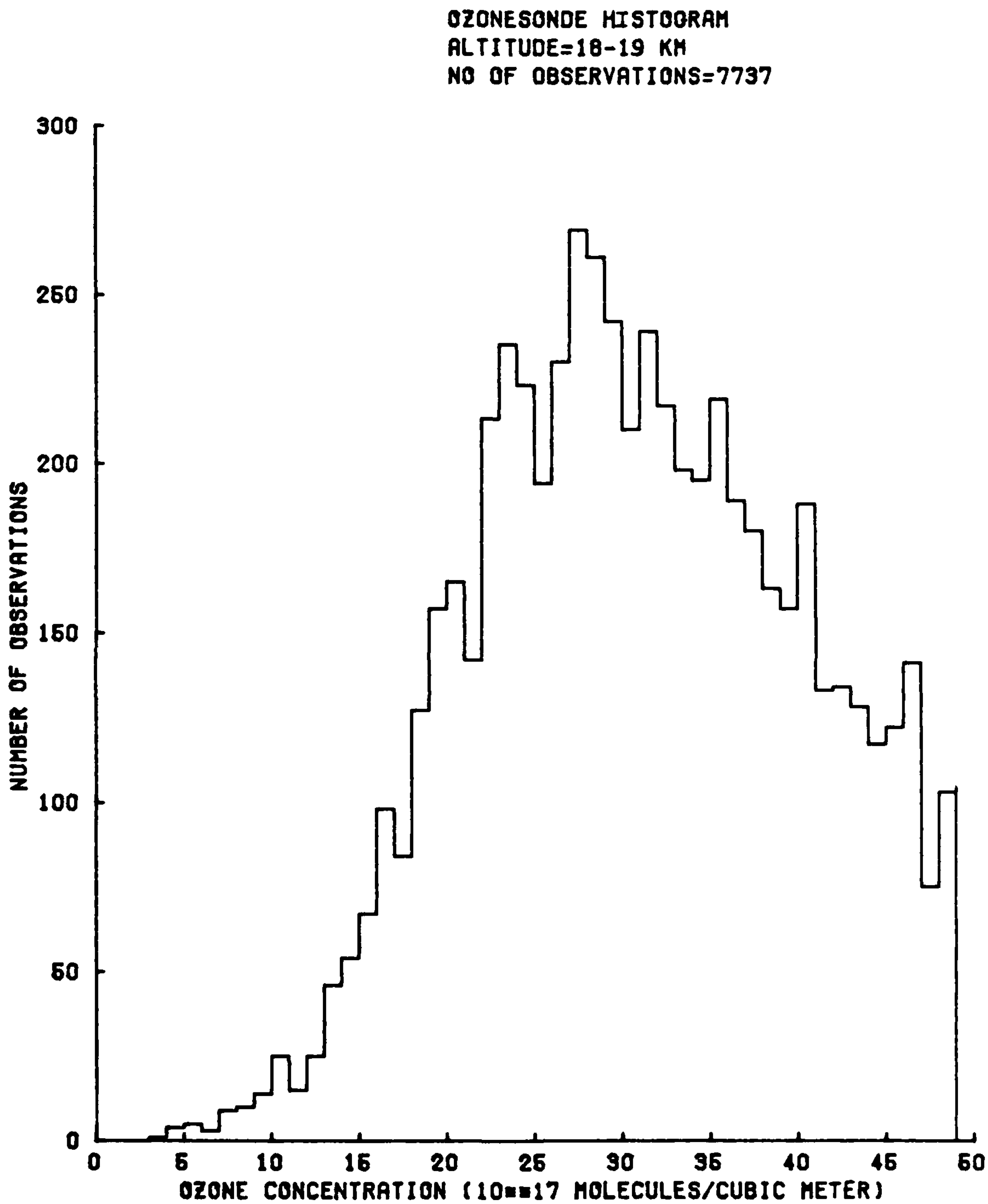

Fig. B19 — Ozone concentration histogram for altitudes between 18 and 19 kilometers

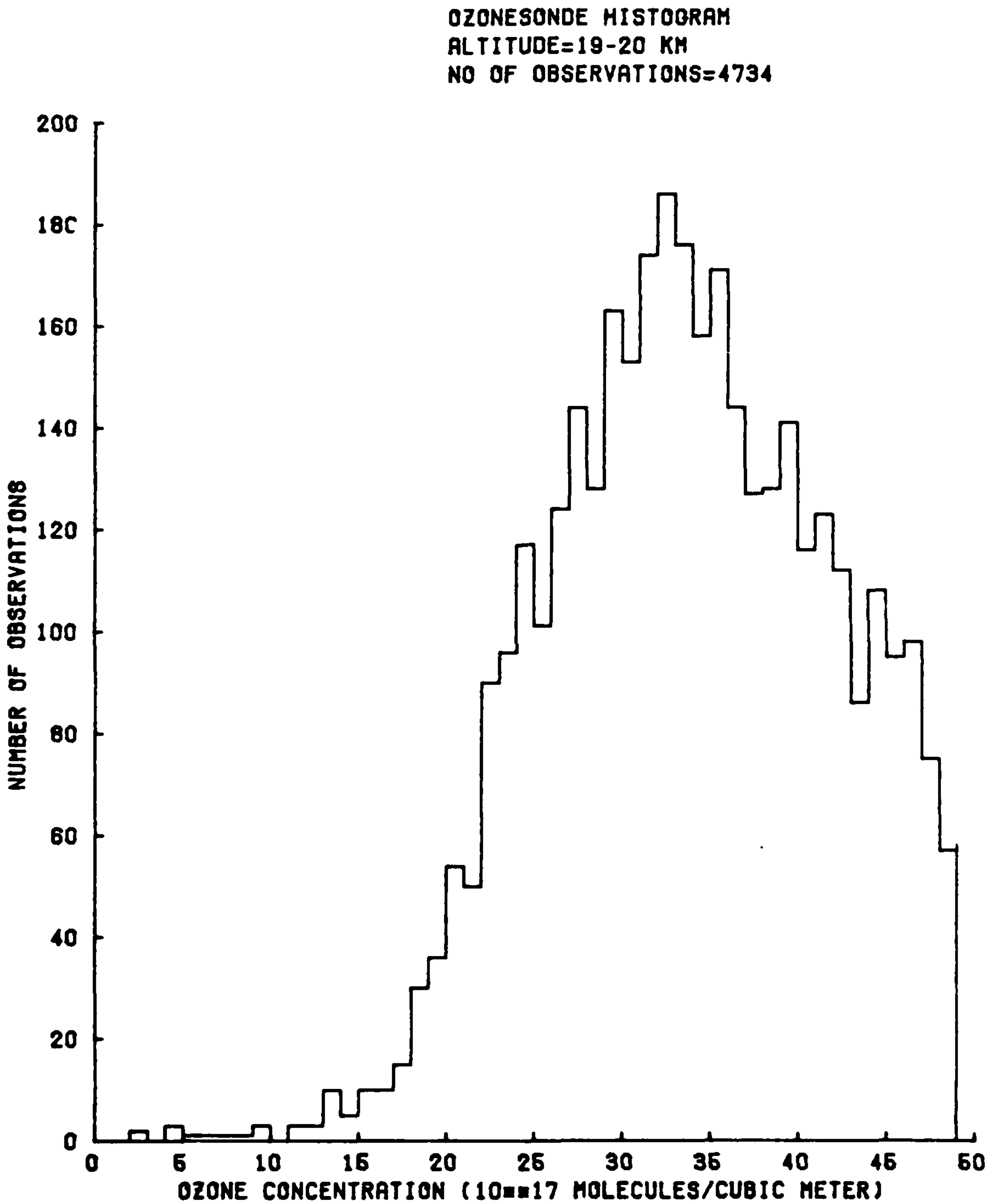

Fig. B20 — Ozone concentration histogram for altitudes between 19 and 20 kilometers

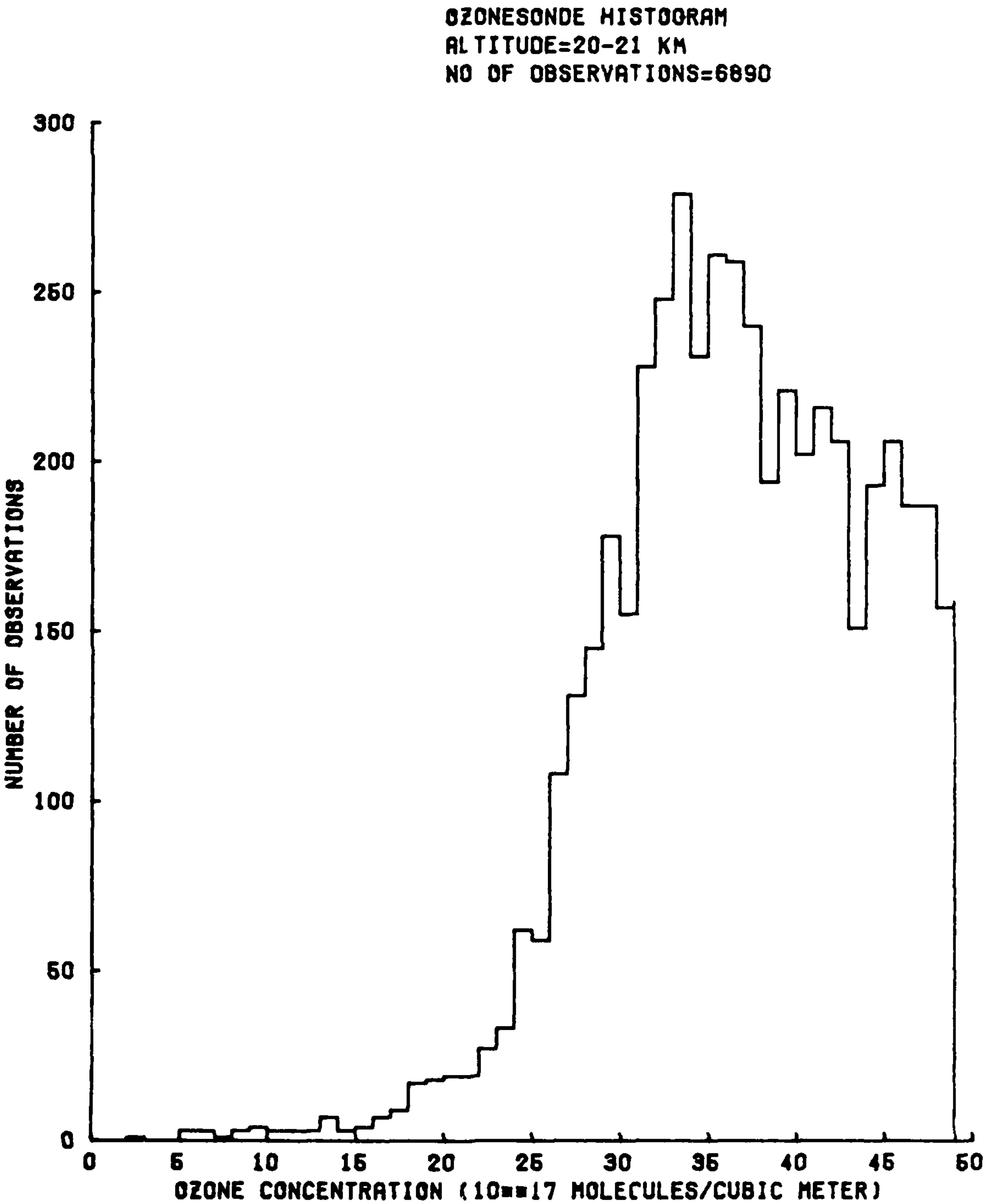

Fig. B21 — Ozone concentration histogram for altitudes between 20 and 21 kilometers

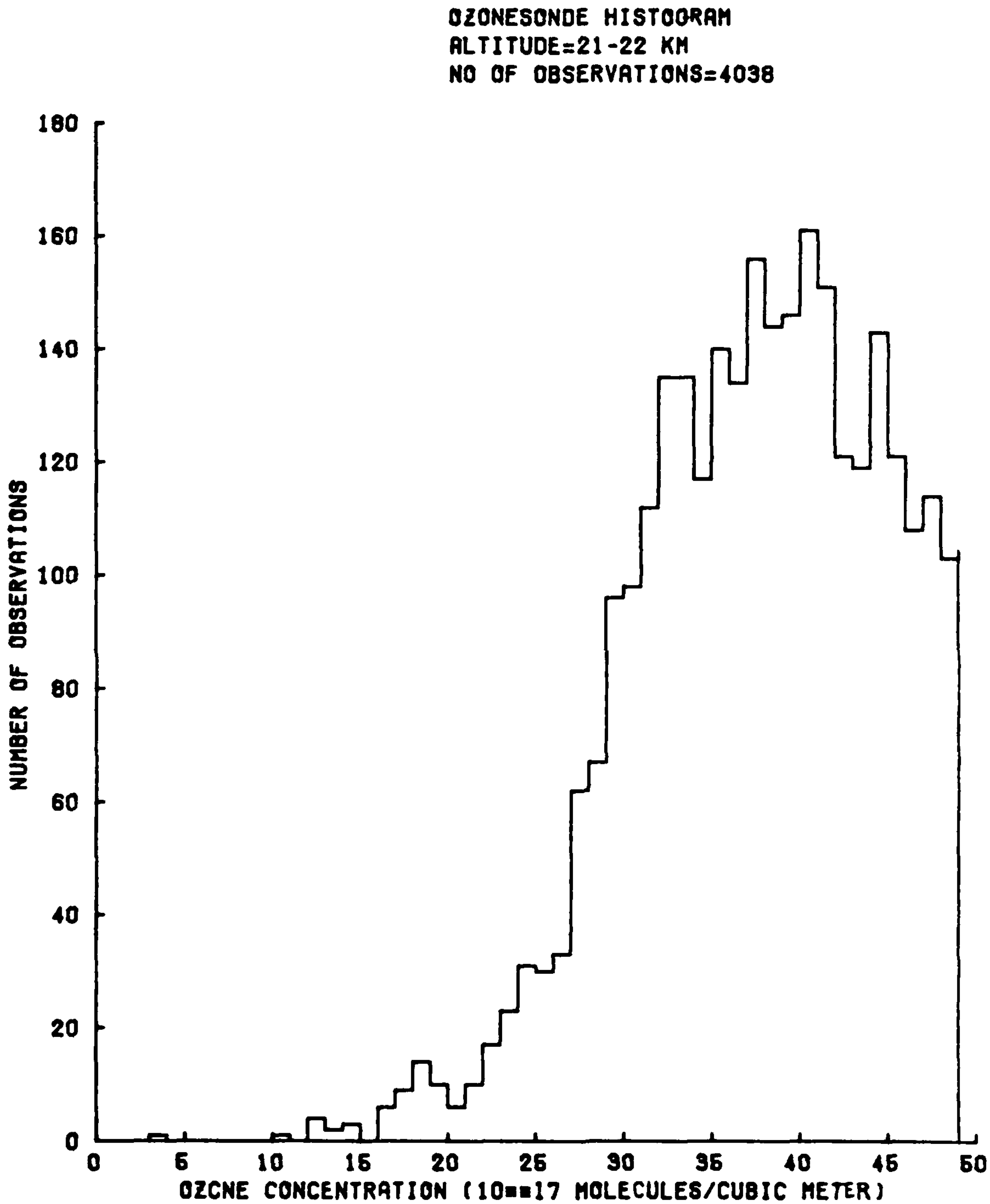

Fig. B22 — Ozone concentration histogram for altitudes between 21 and 22 kilometers

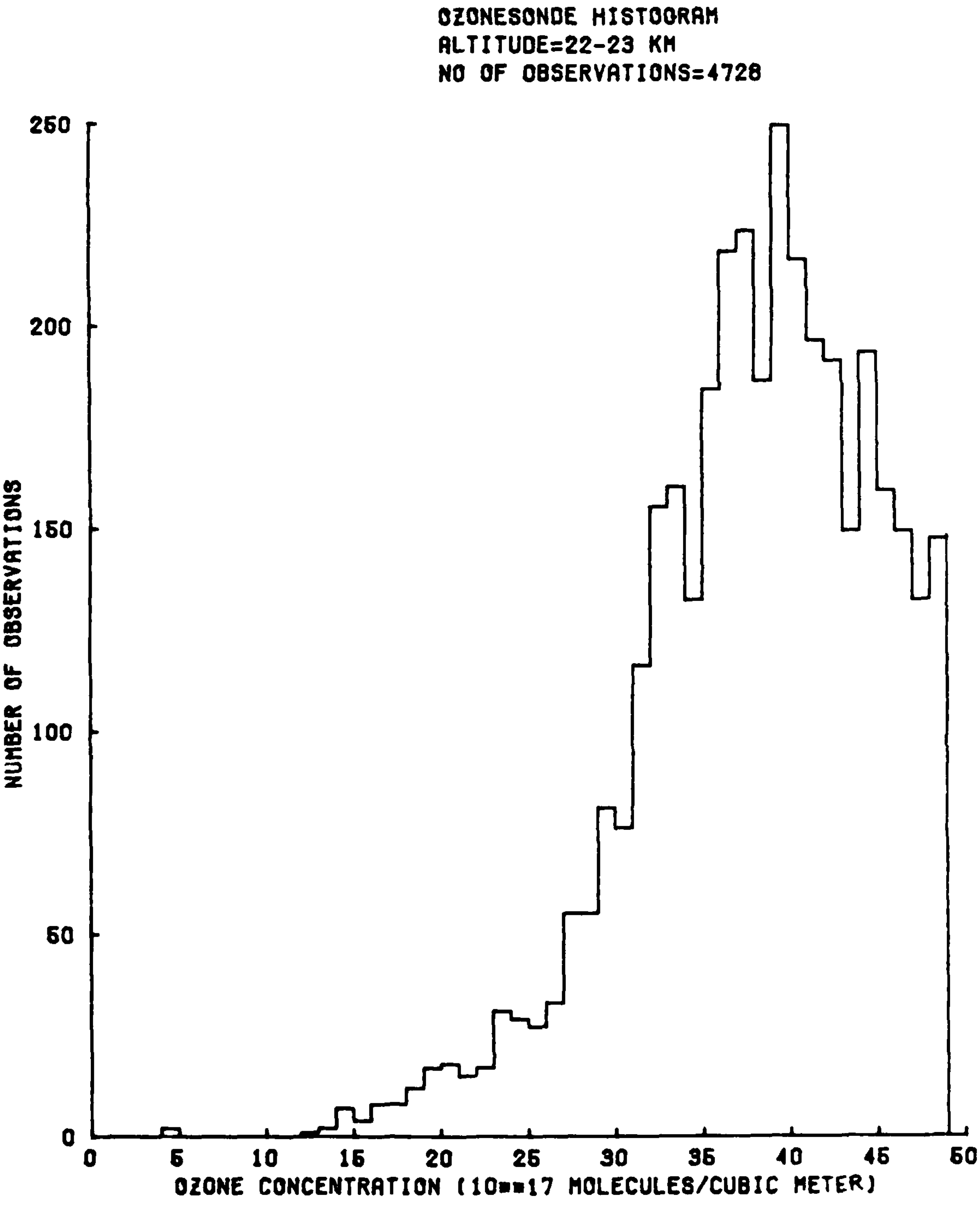

Fig. B23 — Ozone concentration histogram for altitudes between 22 and 23 kilometers

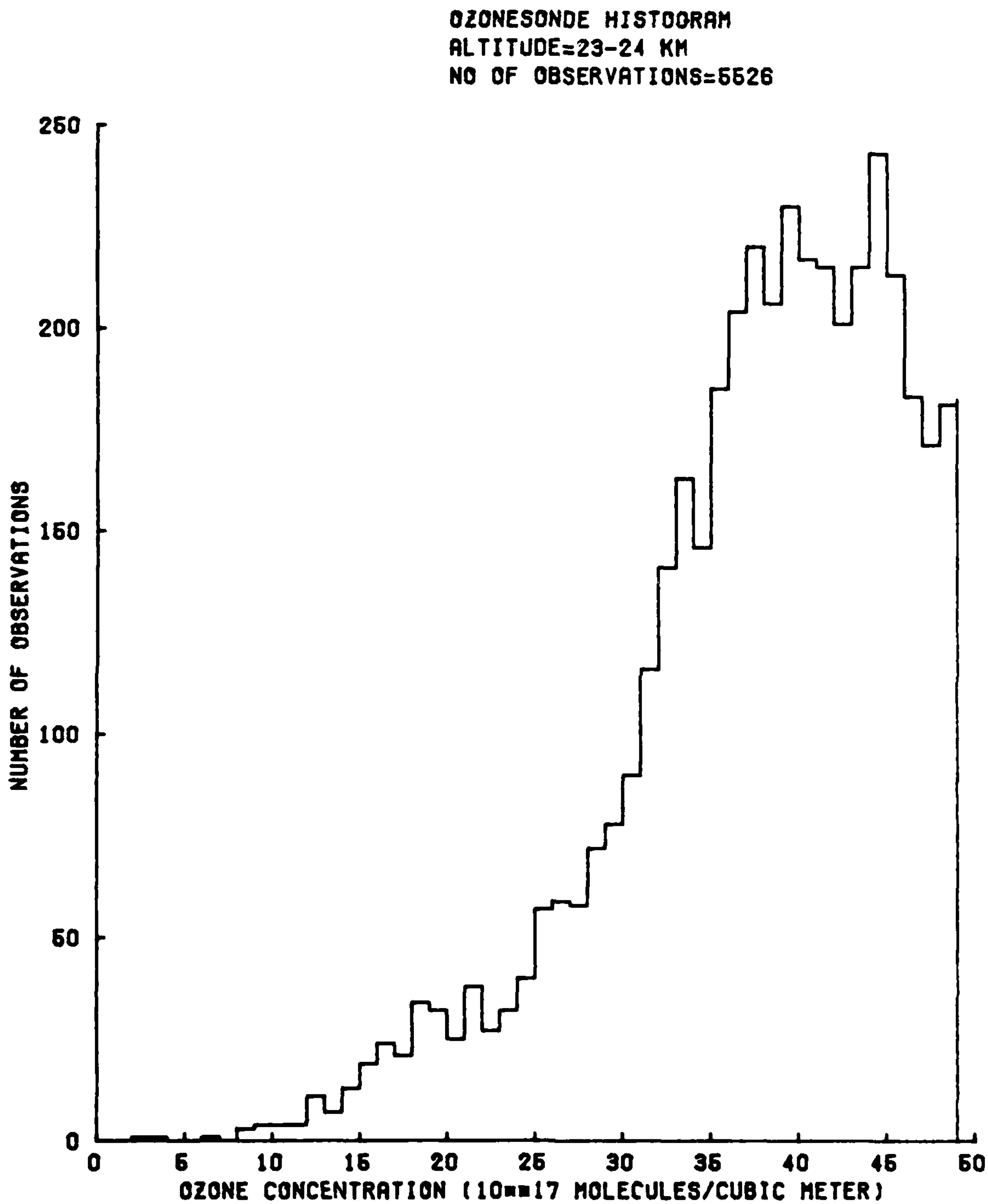

Fig. B24 — Ozone concentration histogram for altitudes between 23 and 24 kilometers

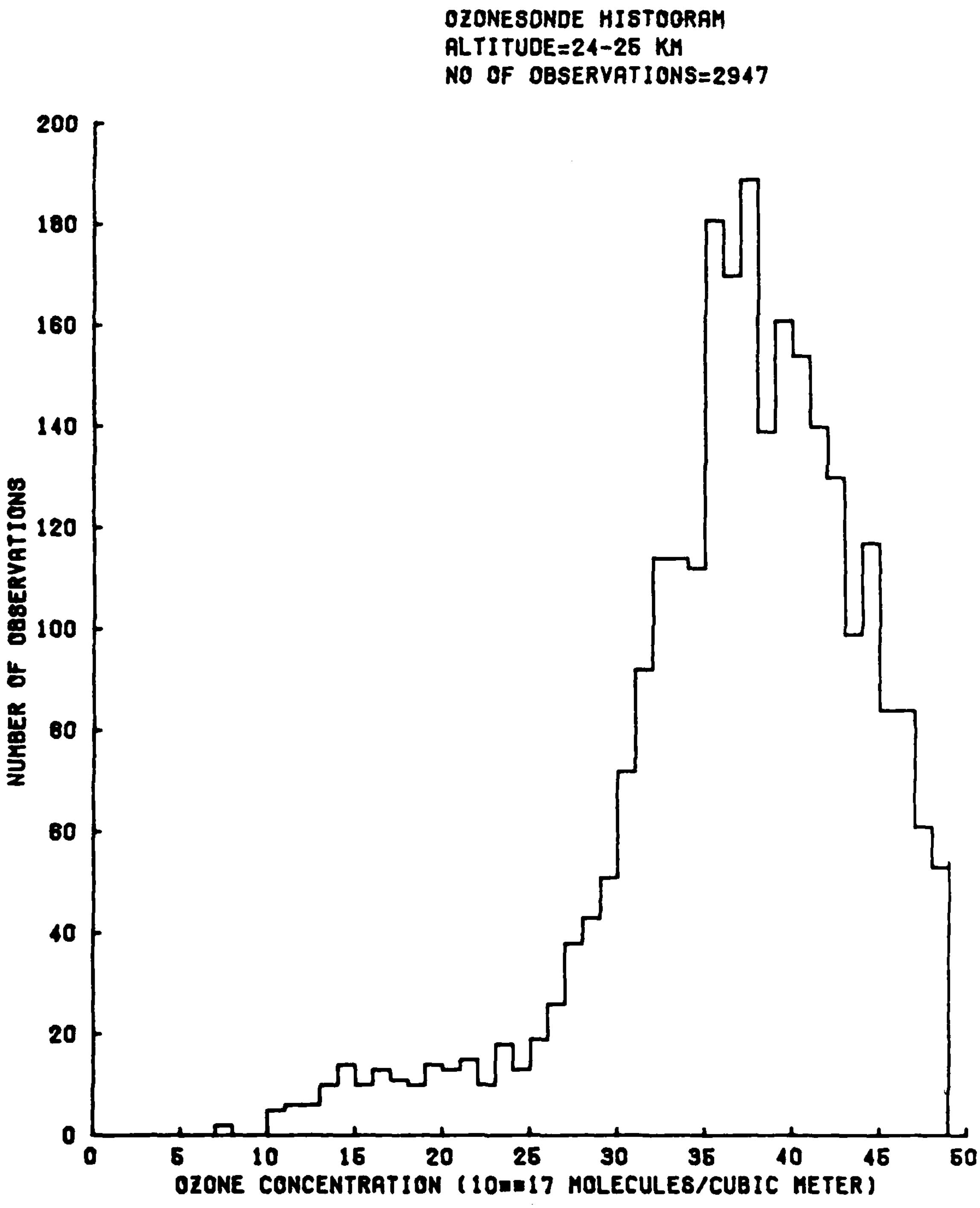

Fig. B25 — Ozone concentration histogram for altitudes between 24 and 25 kilometers

APPENDIX C

Probability of Exceeding Ozone Concentrations for Altitudes up to 25 Kilometers

This appendix contains curves showing the probability of exceeding a given ozone concentration for concentrations up to and including 50×10^{17} molecules per cubic meter. Data up to 100×10^{17} molecules per cubic meter can be found in Table 6.

<u>Note</u> 10**17 is computer notation for 10^{17}.

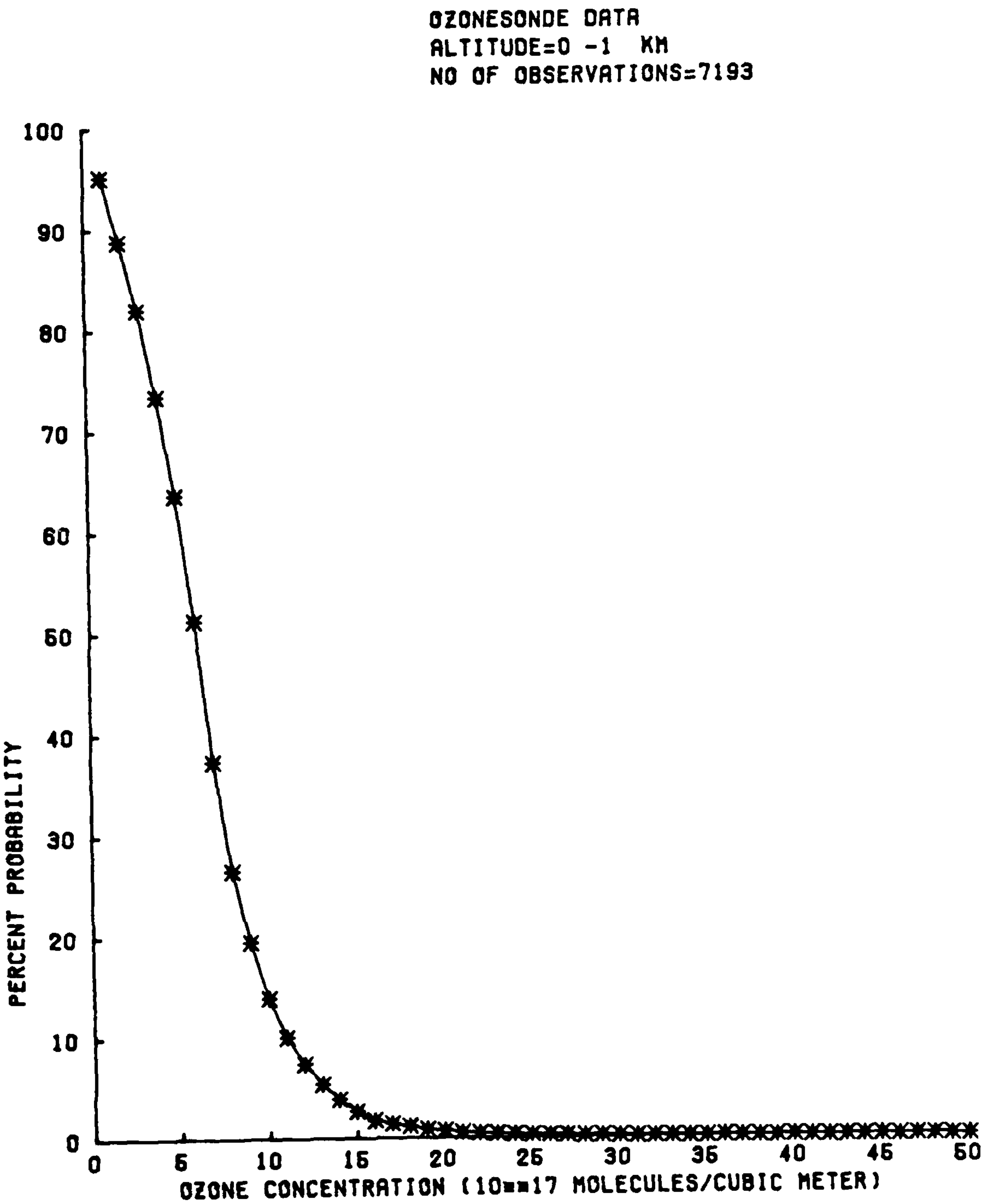

Fig. C1 — Probability of exceeding ozone concentrations for altitudes between 0 and 1 kilometer

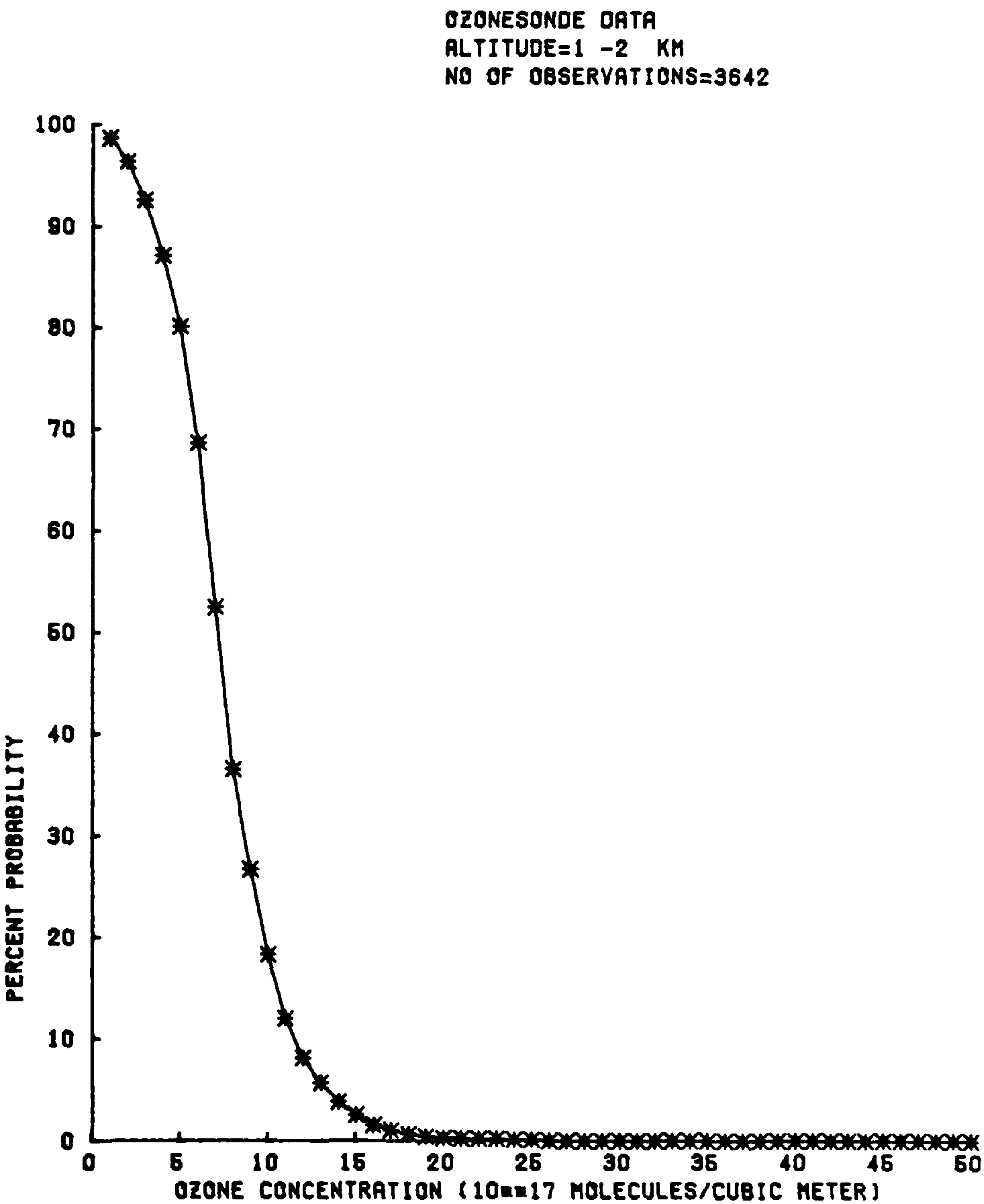

Fig. C2 — Probability of exceeding ozone concentrations for altitudes between 1 and 2 kilometers

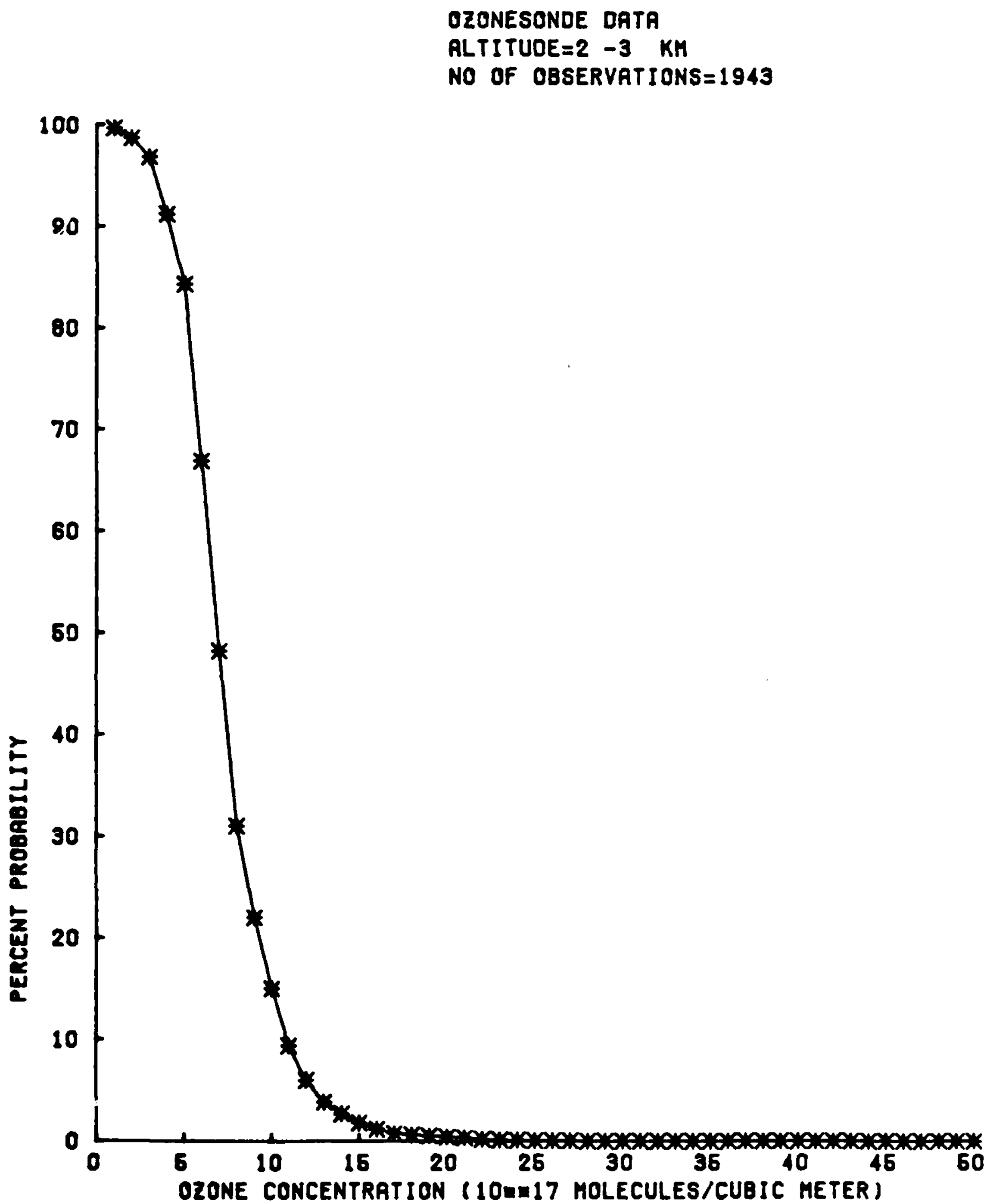

Fig. C3 — Probability of exceeding ozone concentrations for altitudes between 2 and 3 kilometers

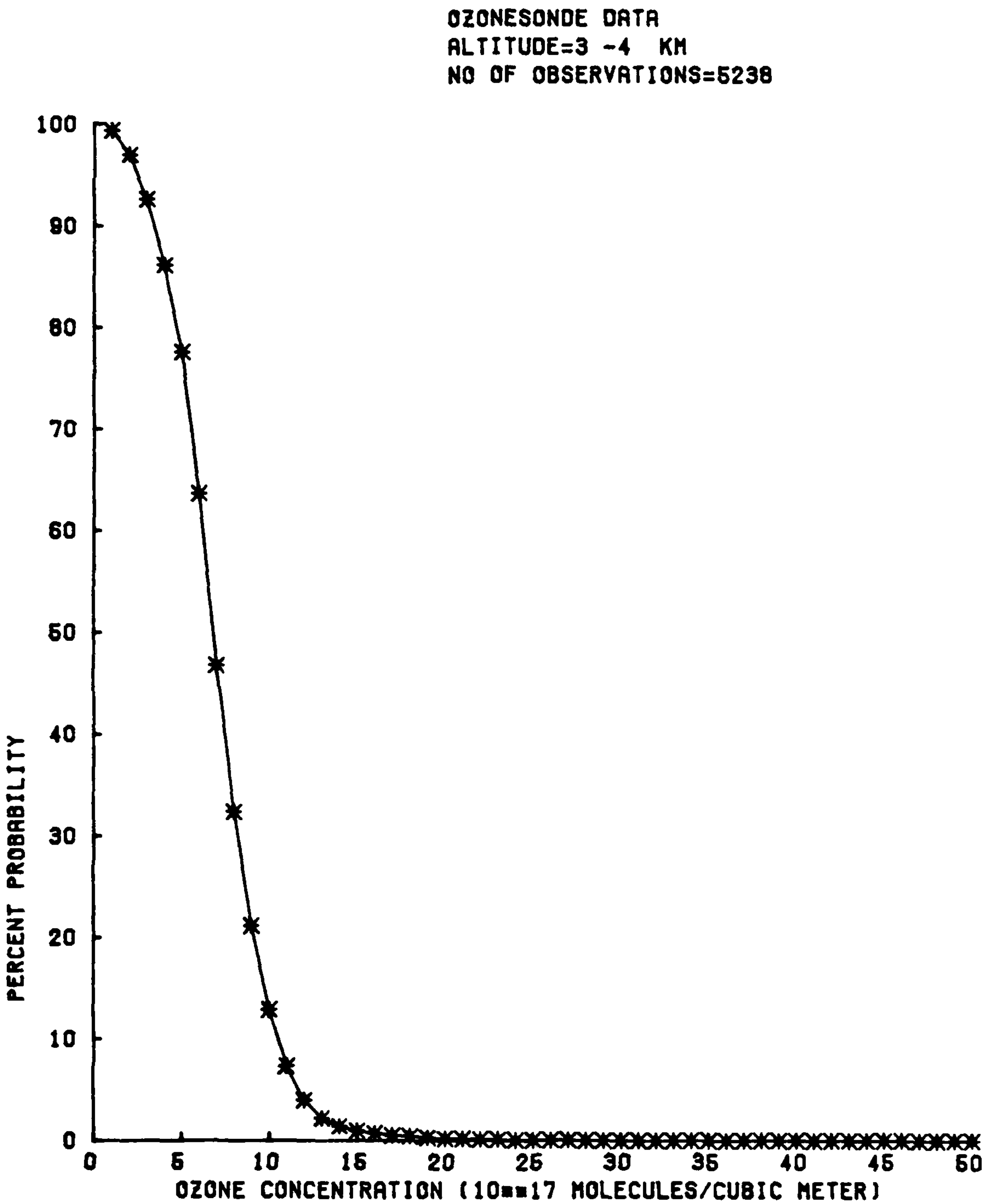

Fig. C4 — Probability of exceeding ozone concentrations for altitudes between 3 and 4 kilometers

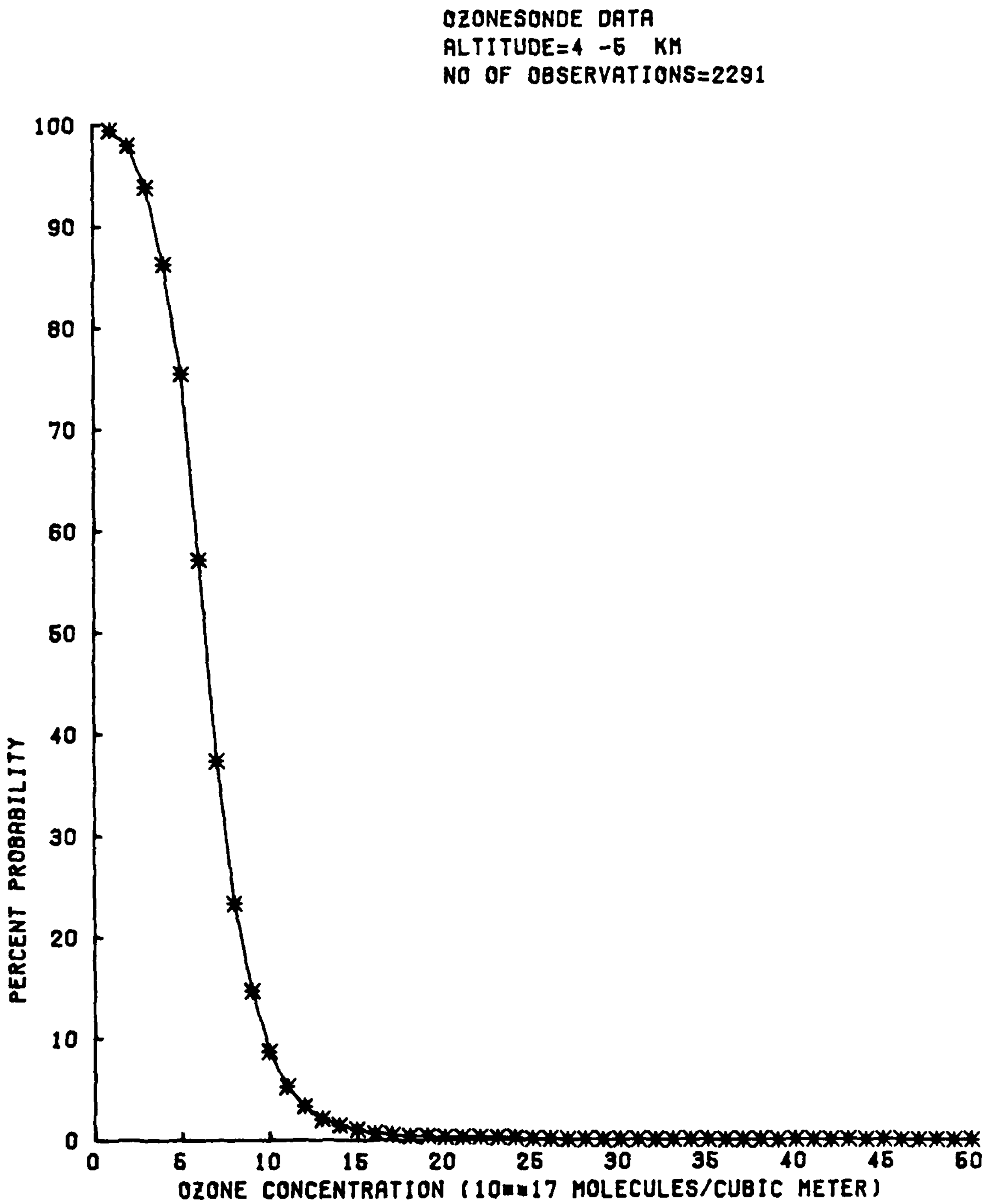

Fig. C5 — Probability of exceeding ozone concentrations for altitudes between 4 and 5 kilometers

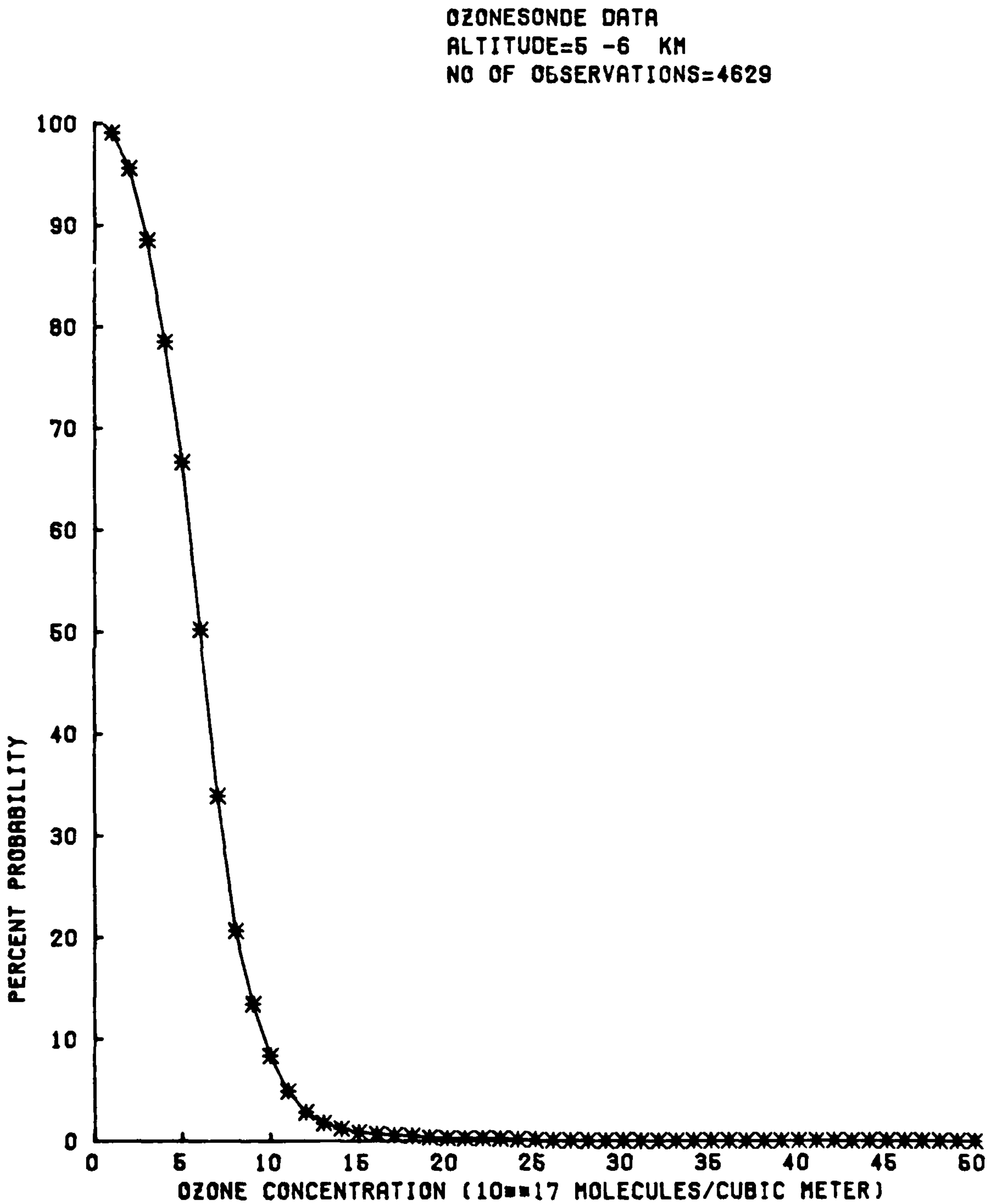

Fig. C6 — Probability of exceeding ozone concentrations for altitudes between 5 and 6 kilometers

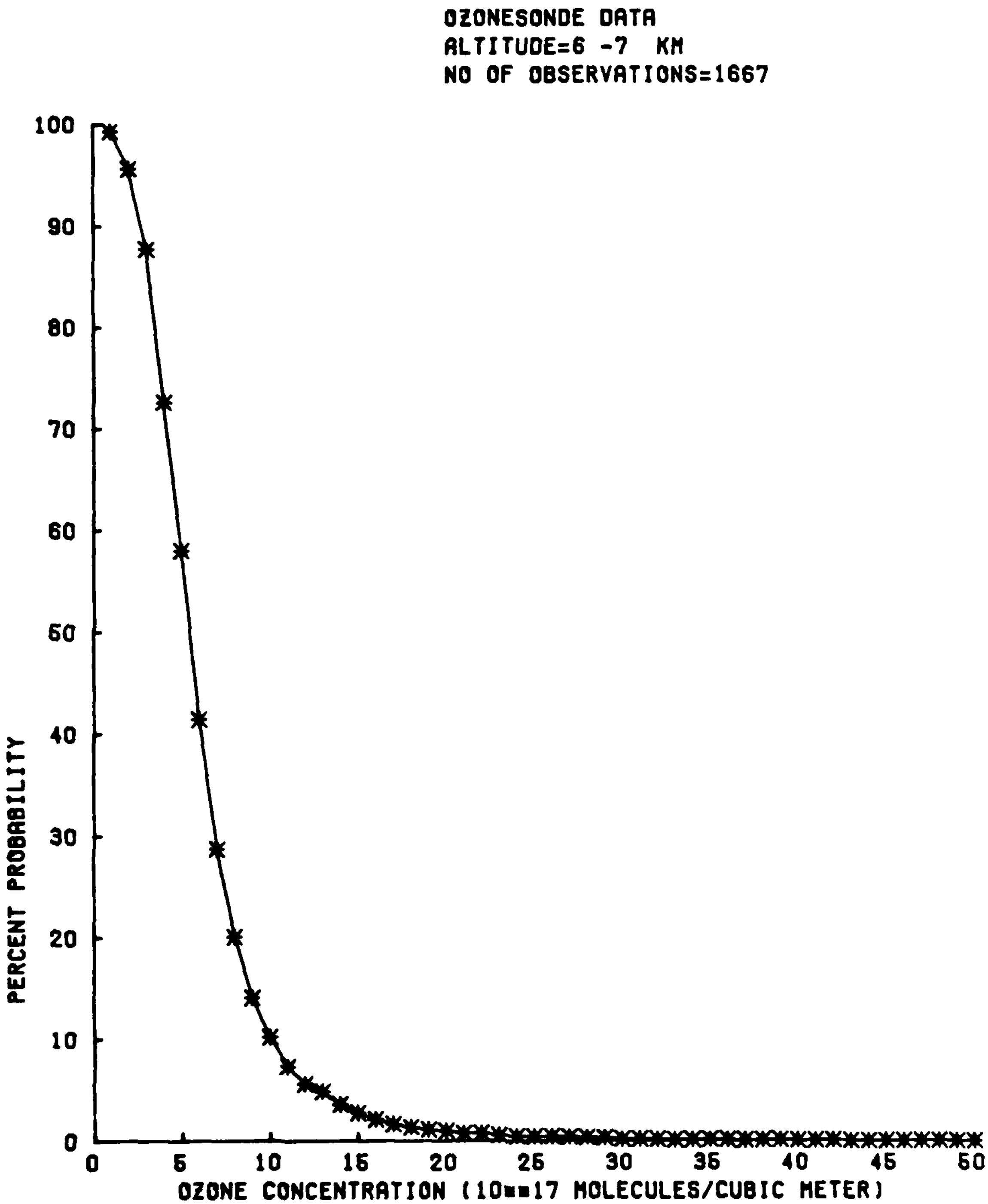

Fig. C7 — Probability of exceeding ozone concentrations for altitudes between 6 and 7 kilometers

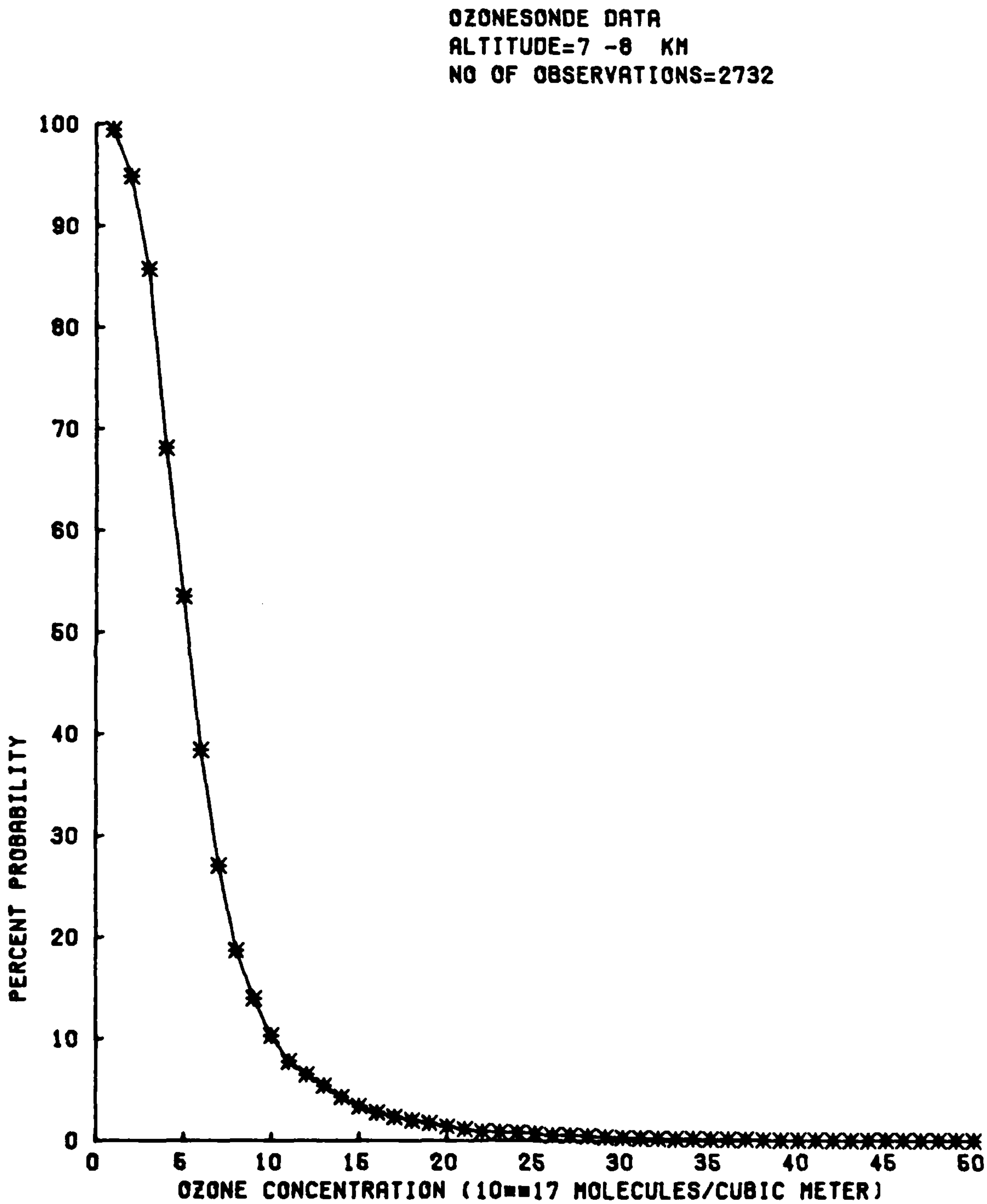

Fig. C8 — Probability of exceeding ozone concentrations for altitudes between 7 and 8 kilometers

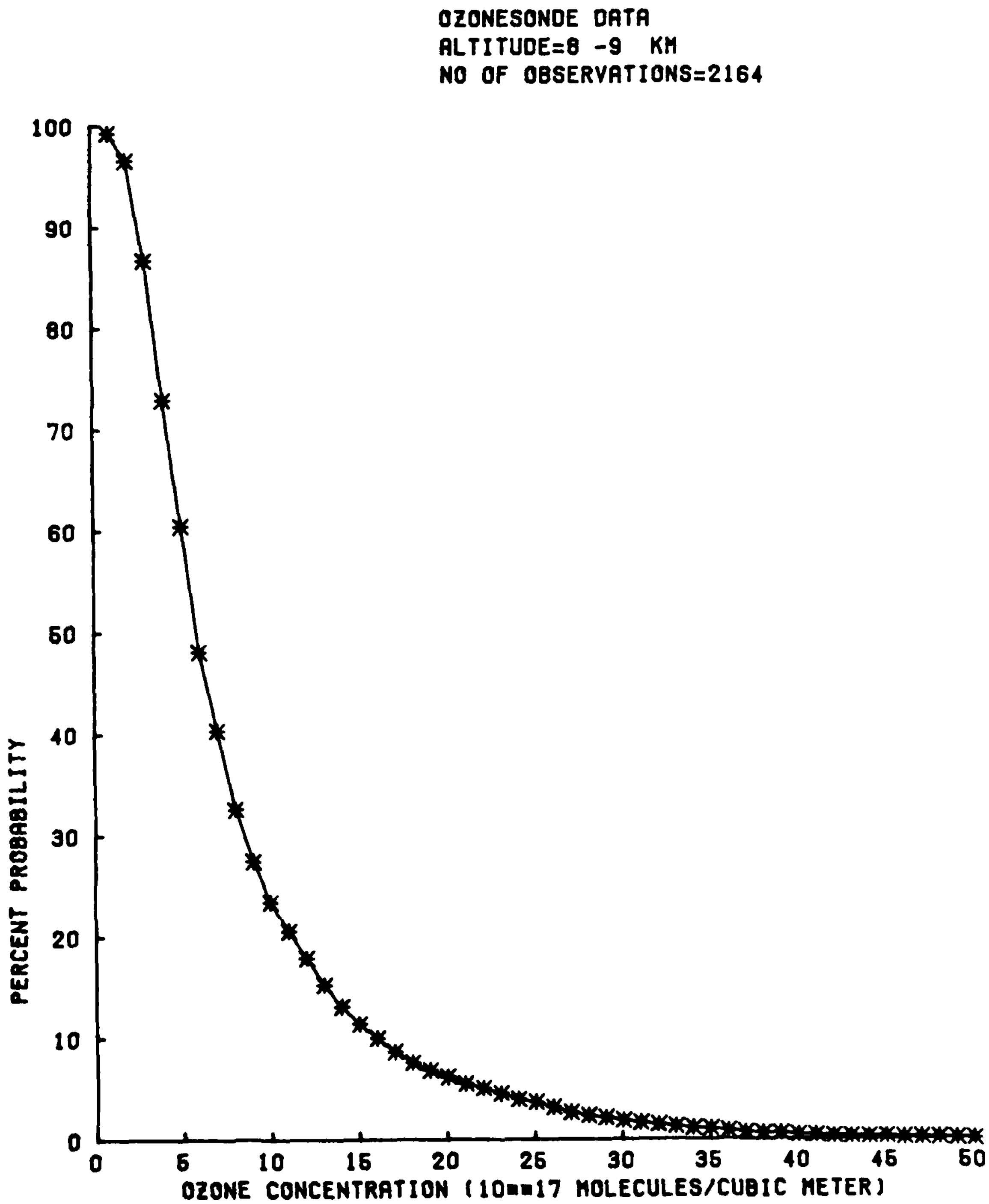

Fig. C9 — Probability of exceeding ozone concentrations for altitudes between 8 and 9 kilometers

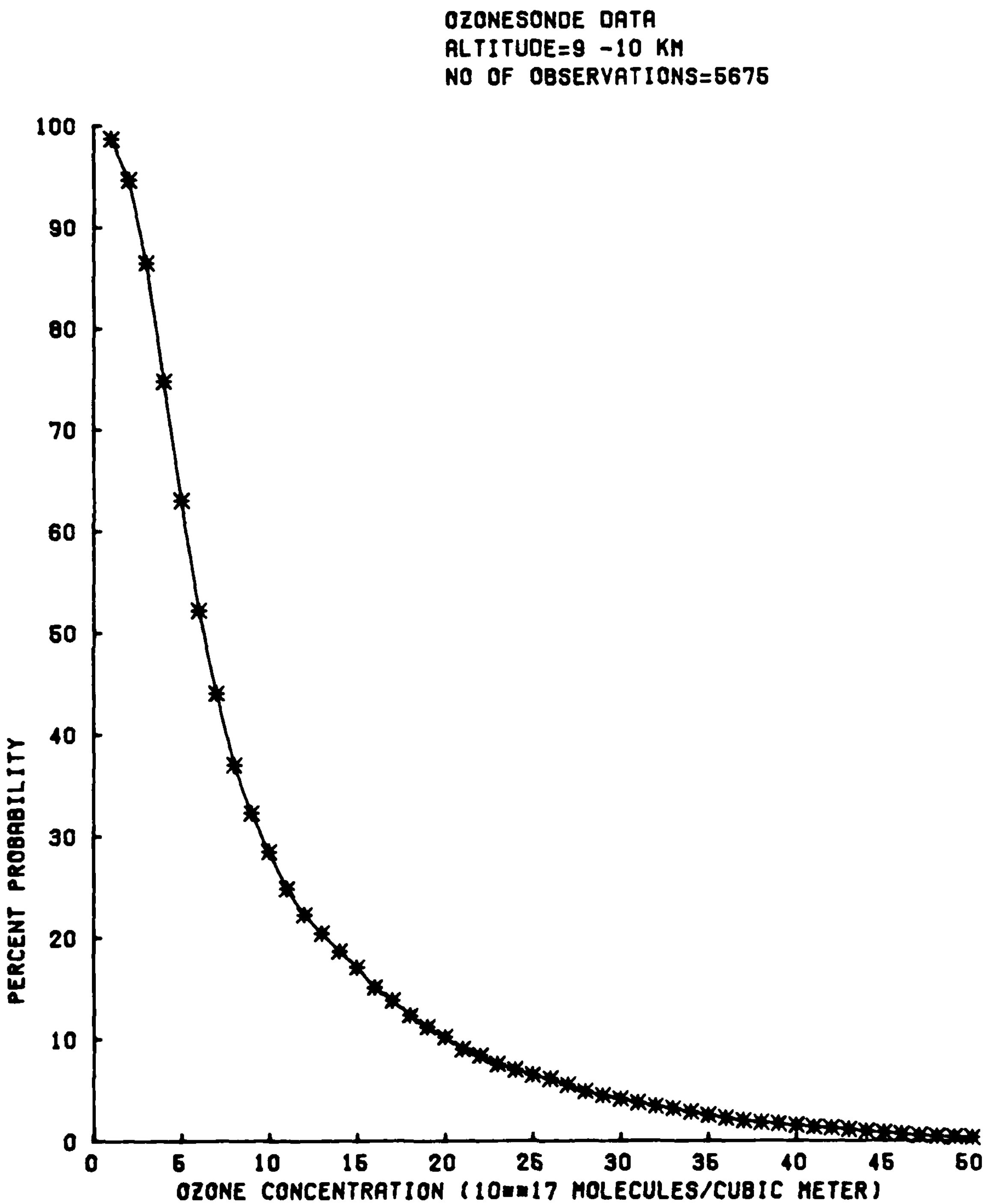

Fig. C10 — Probability of exceeding ozone concentrations for altitudes between 9 and 10 kilometers

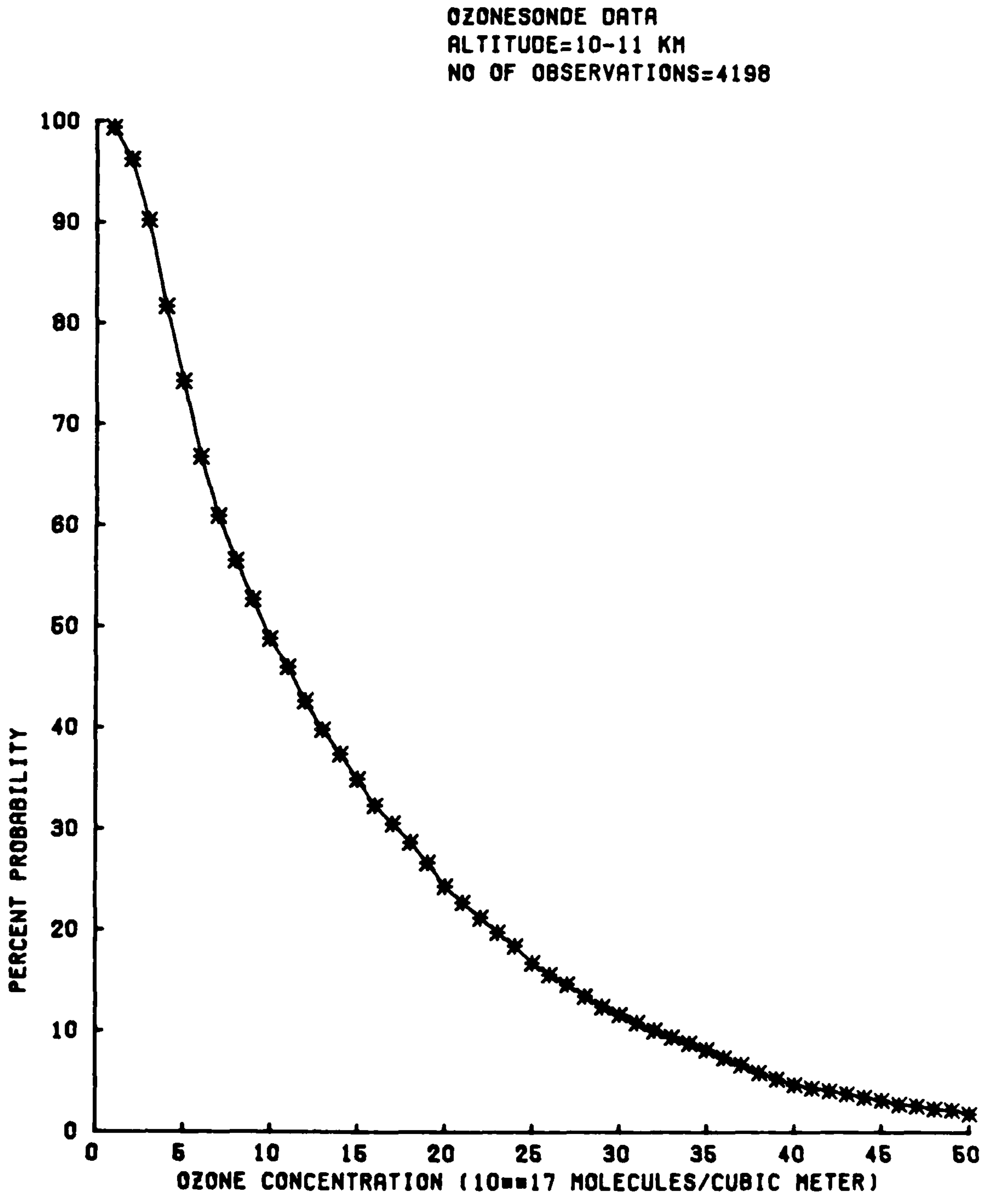

Fig. C11 — Probability of exceeding ozone concentrations for altitudes between 10 and 11 kilometers

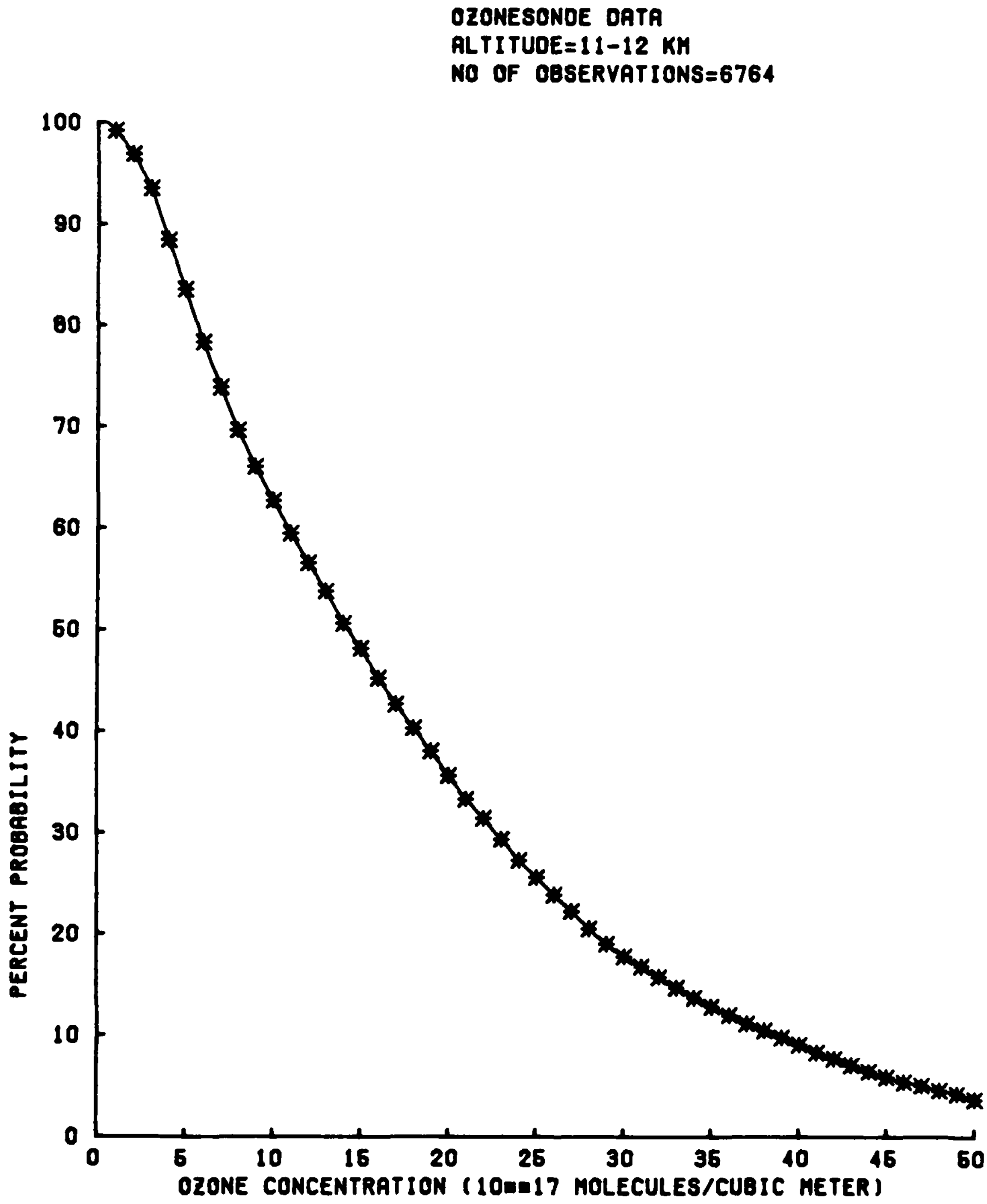

Fig. C12 — Probability of exceeding ozone concentrations for altitudes between 11 and 12 kilometers

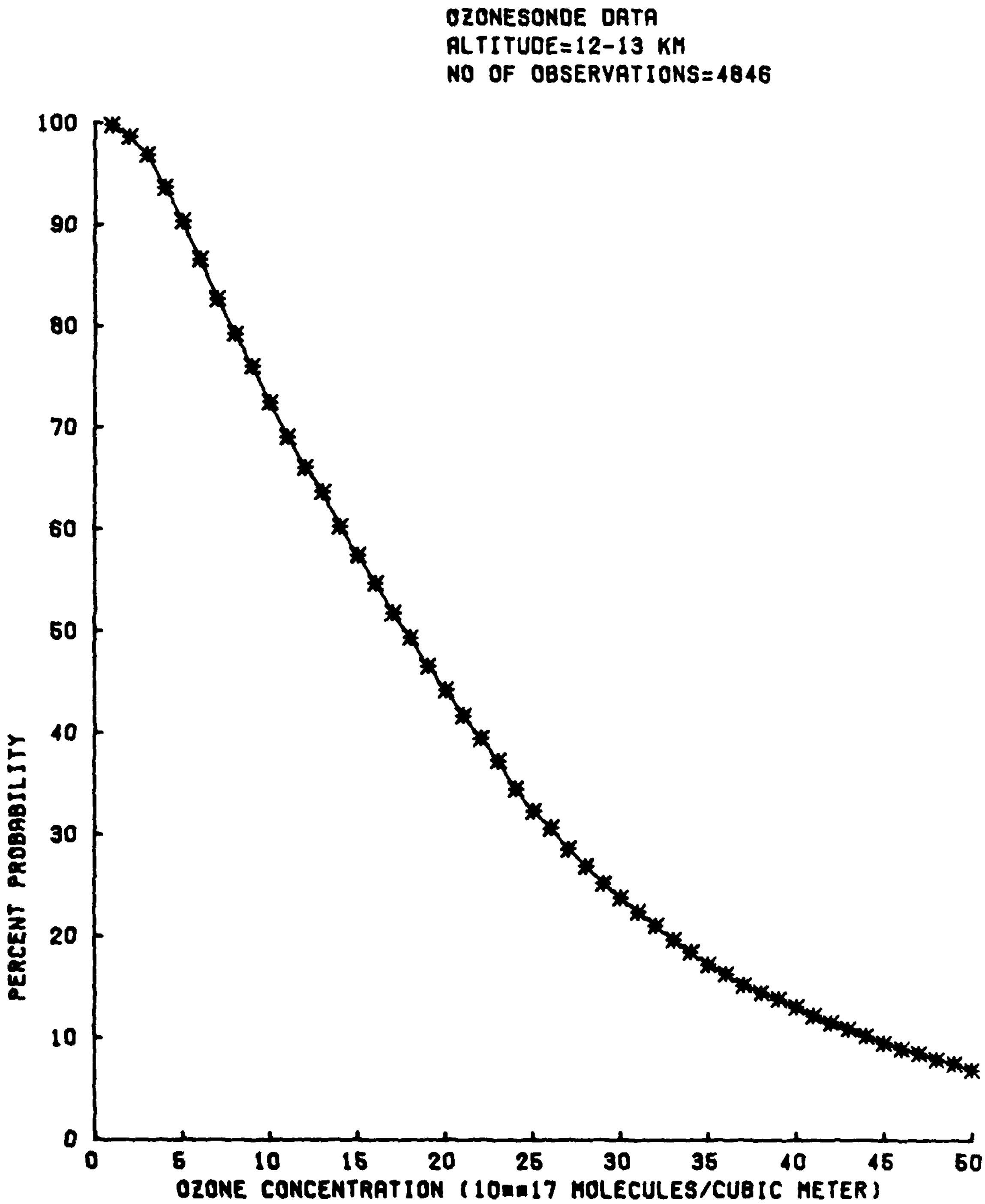

Fig. C13 — Probability of exceeding ozone concentrations for altitudes between 12 and 13 kilometers

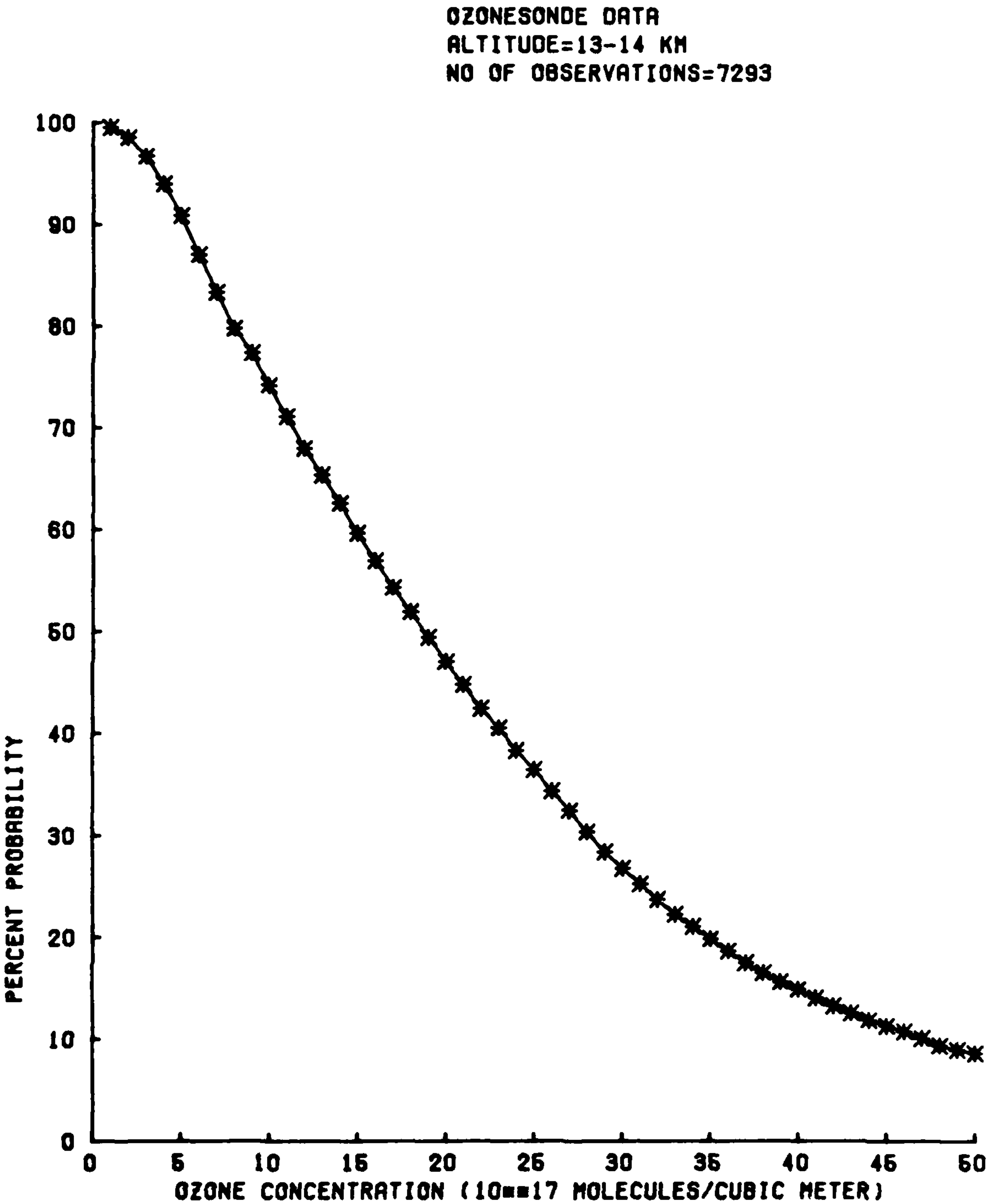

Fig. C14 — Probability of exceeding ozone concentrations for altitudes between 13 and 14 kilometers

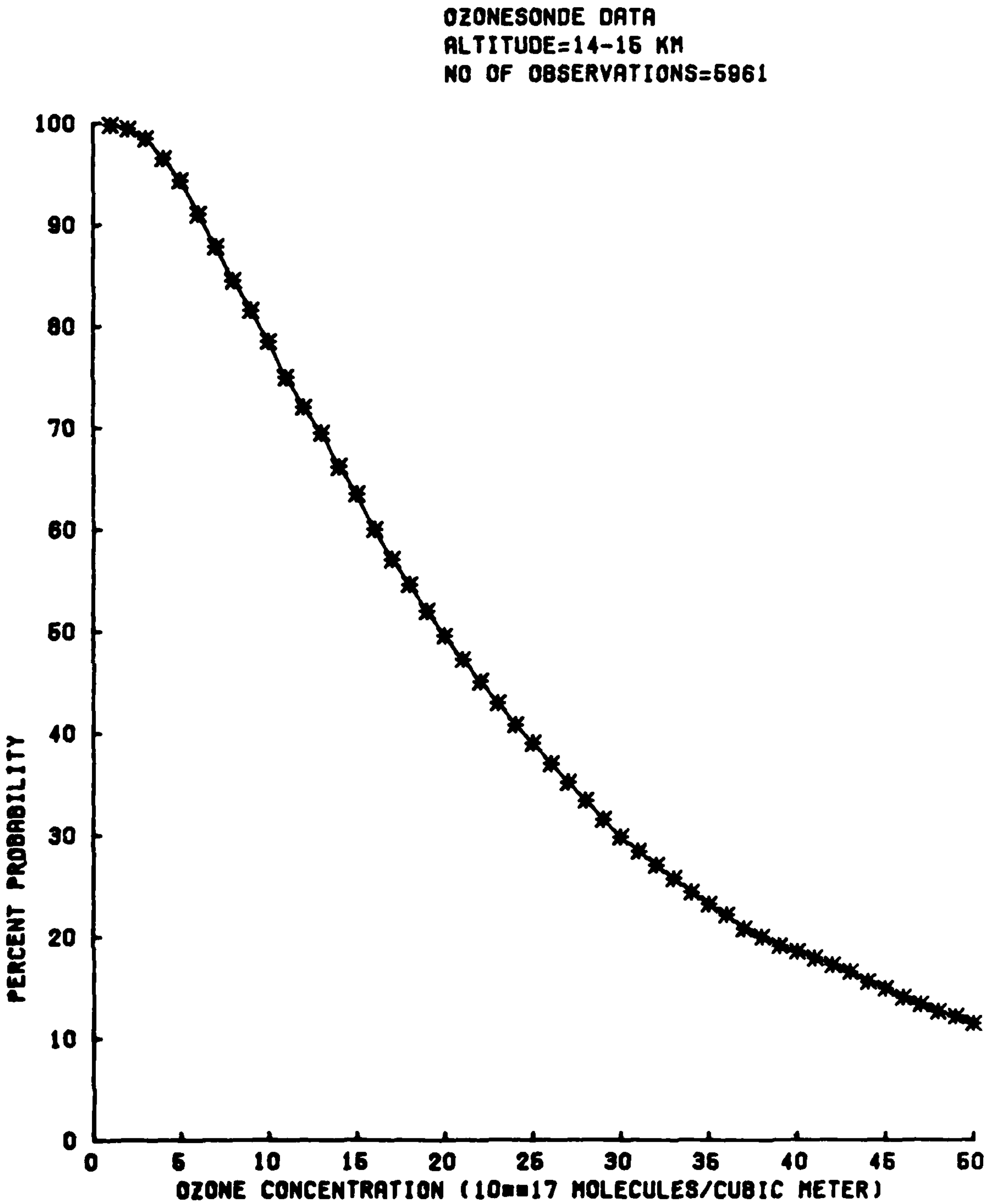

Fig. C15 — Probability of exceeding ozone concentrations for altitudes between 14 and 15 kilometers

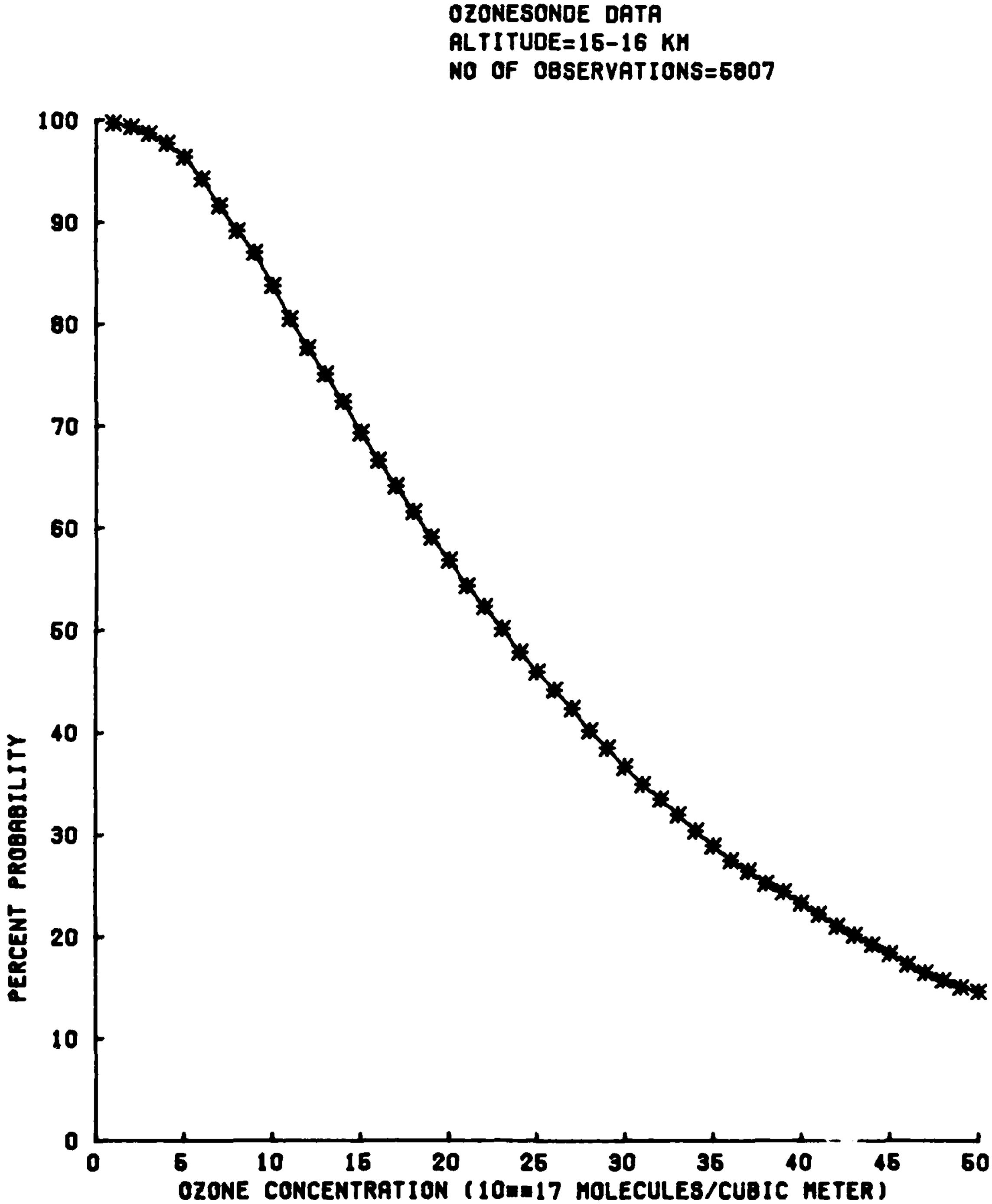

Fig. C16 — Probability of exceeding ozone concentrations for altitudes between 15 and 16 kilometers

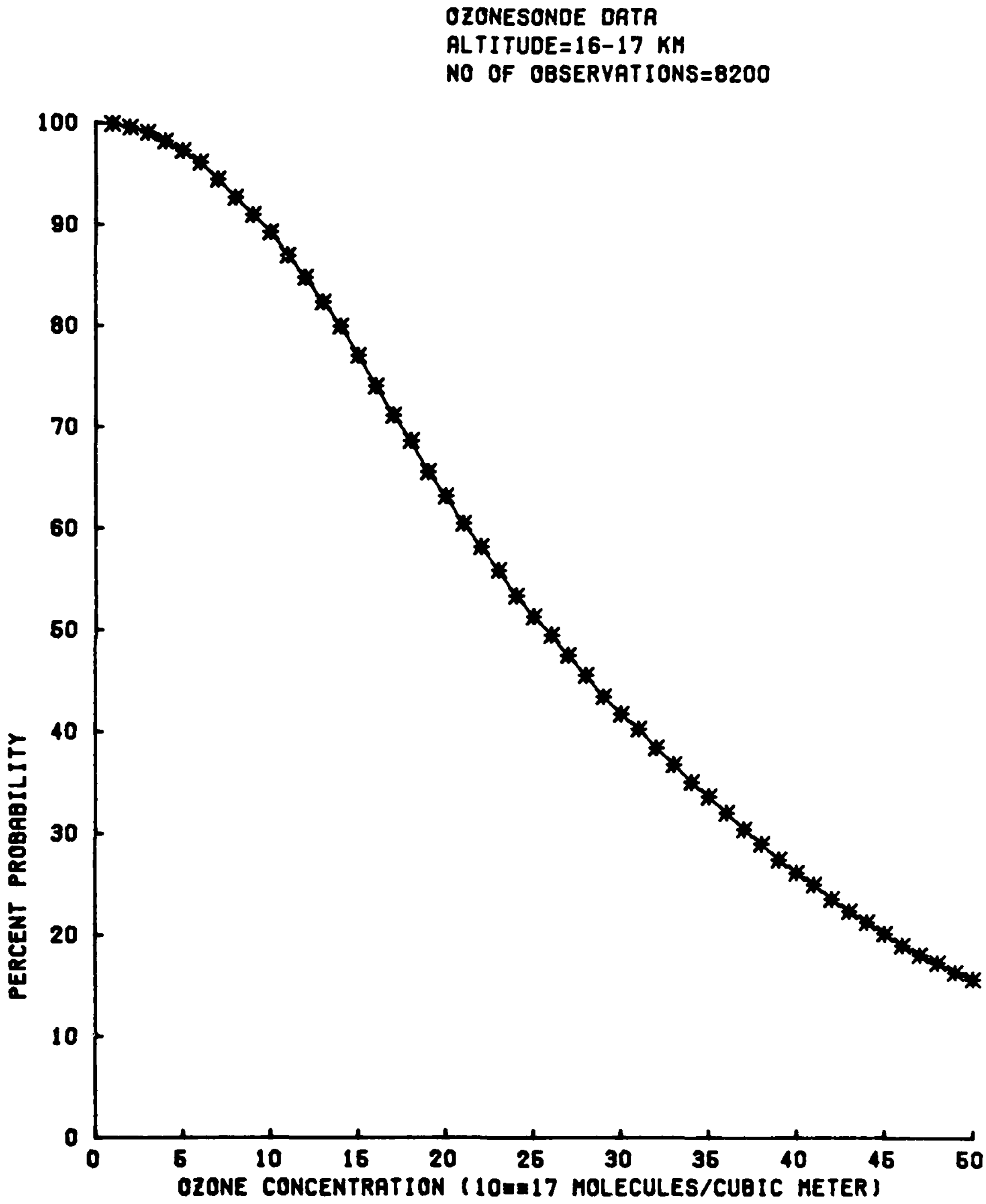

Fig. C17 — Probability of exceeding ozone concentrations for altitudes between 16 and 17 kilometers

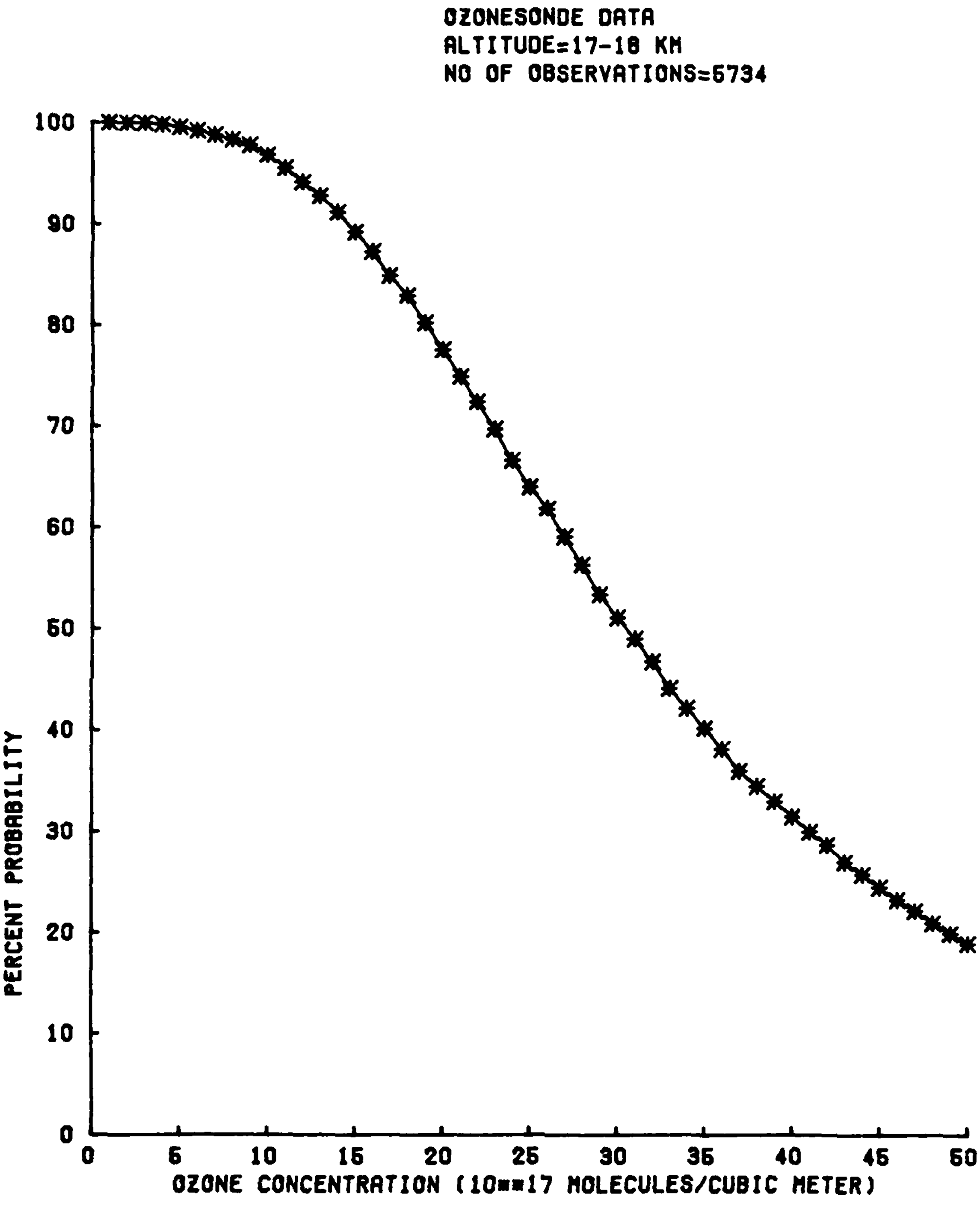

Fig. C18 — Probability of exceeding ozone concentrations for altitudes between 17 and 18 kilometers

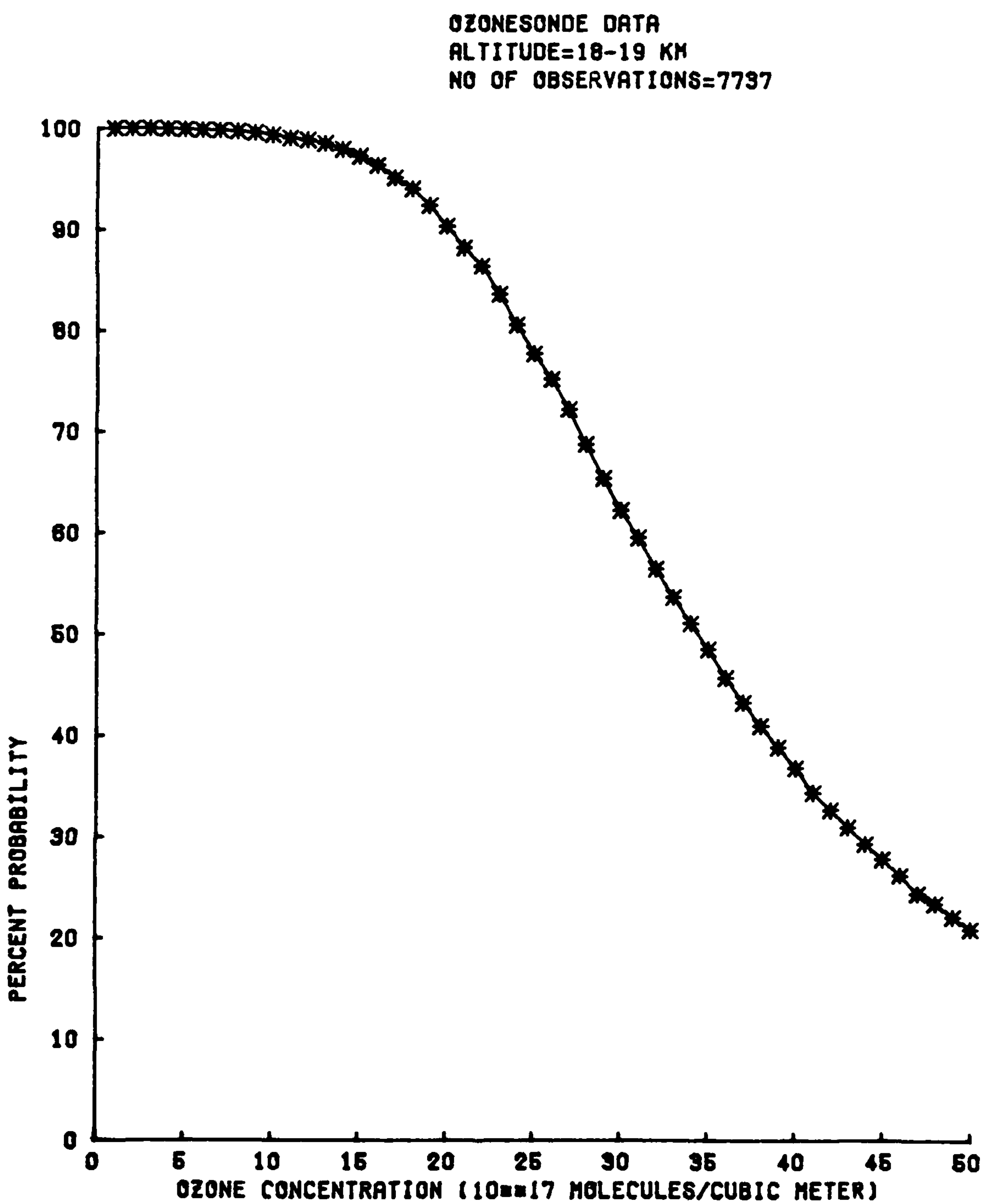

Fig. C19 — Probability of exceeding ozone concentrations for altitudes between 18 and 19 kilometers

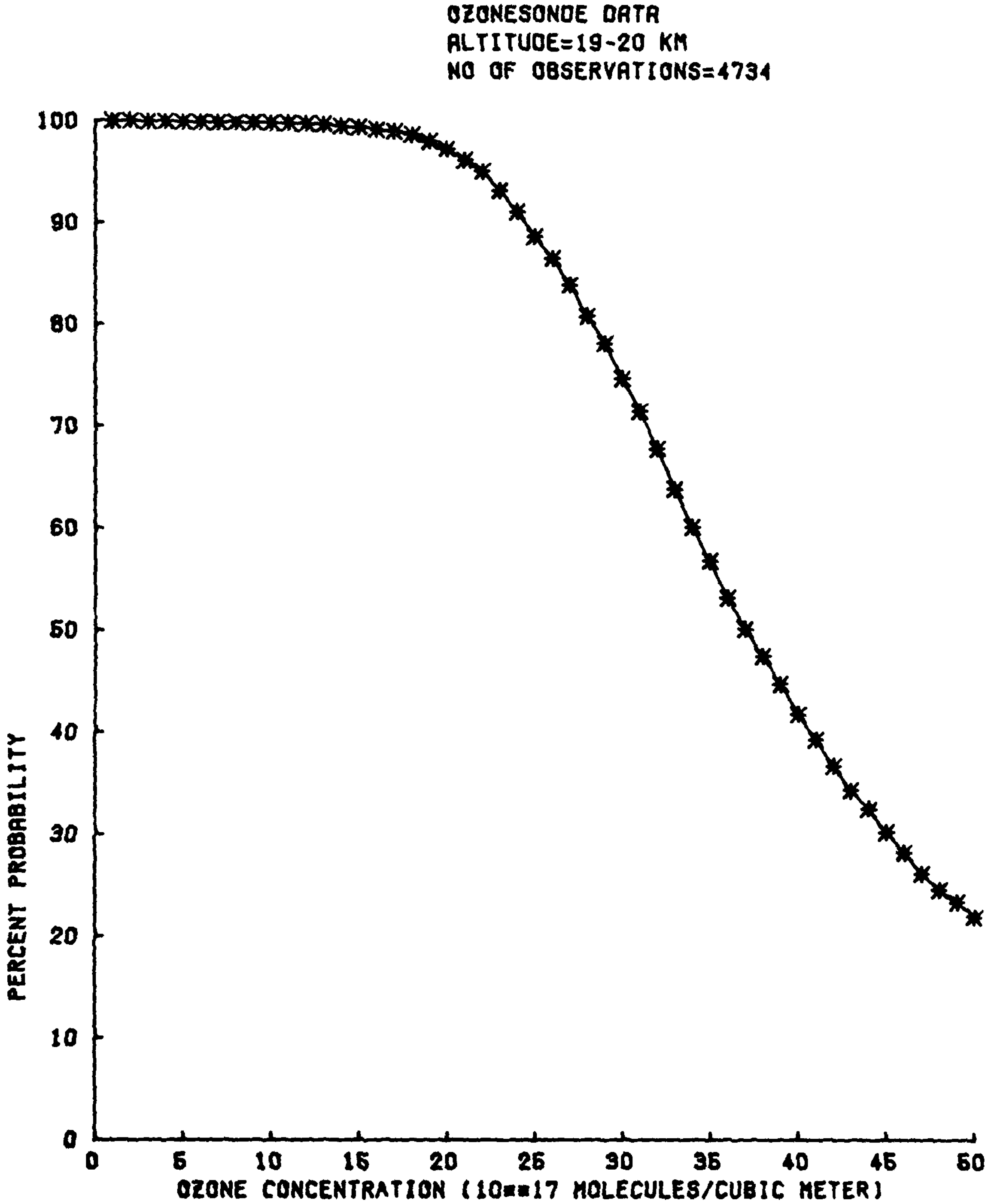

Fig. C20 — Probability of exceeding ozone concentrations for altitudes between 19 and 20 kilometers

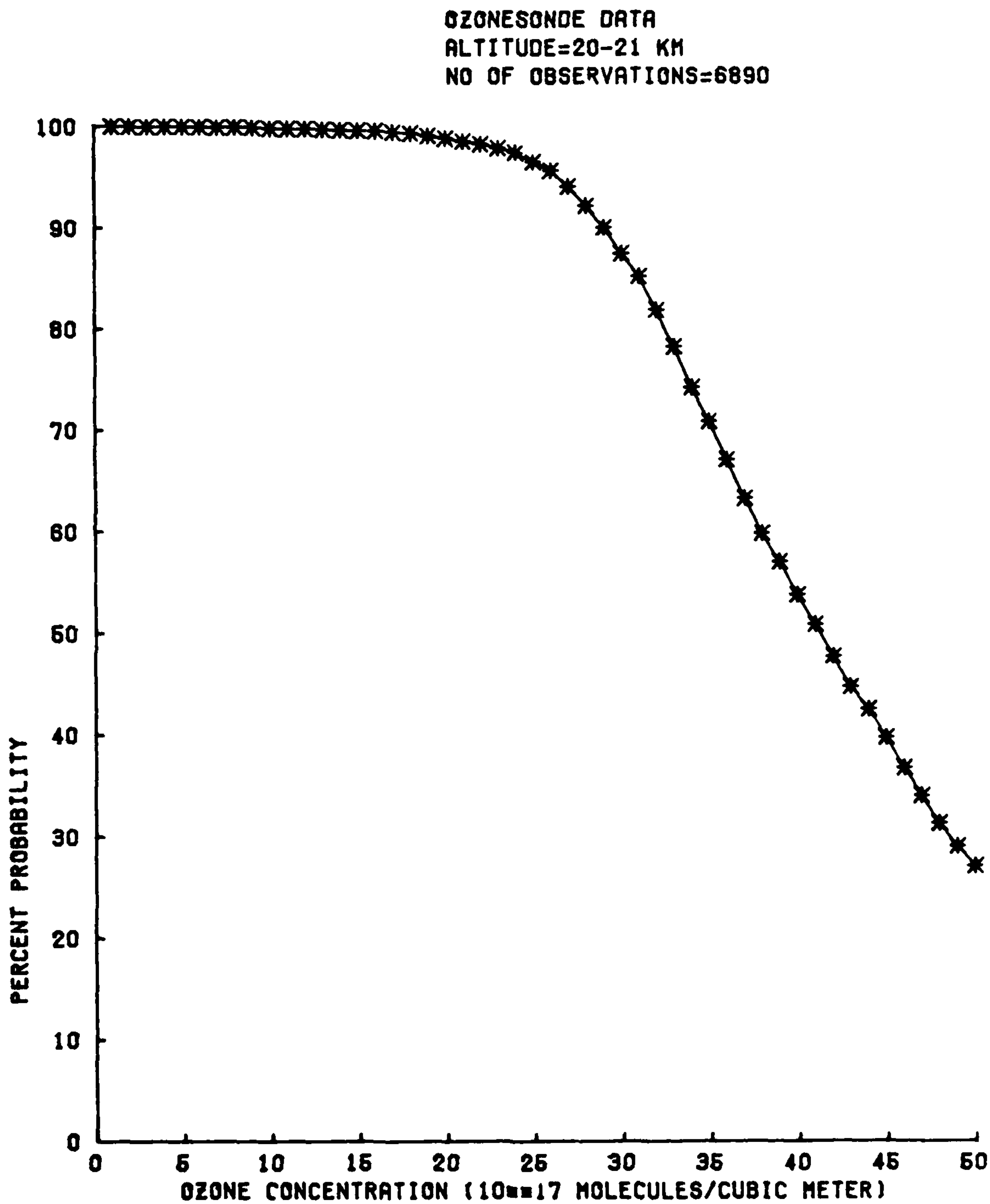

Fig. C21 — Probability of exceeding ozone concentrations for altitudes between 20 and 21 kilometers

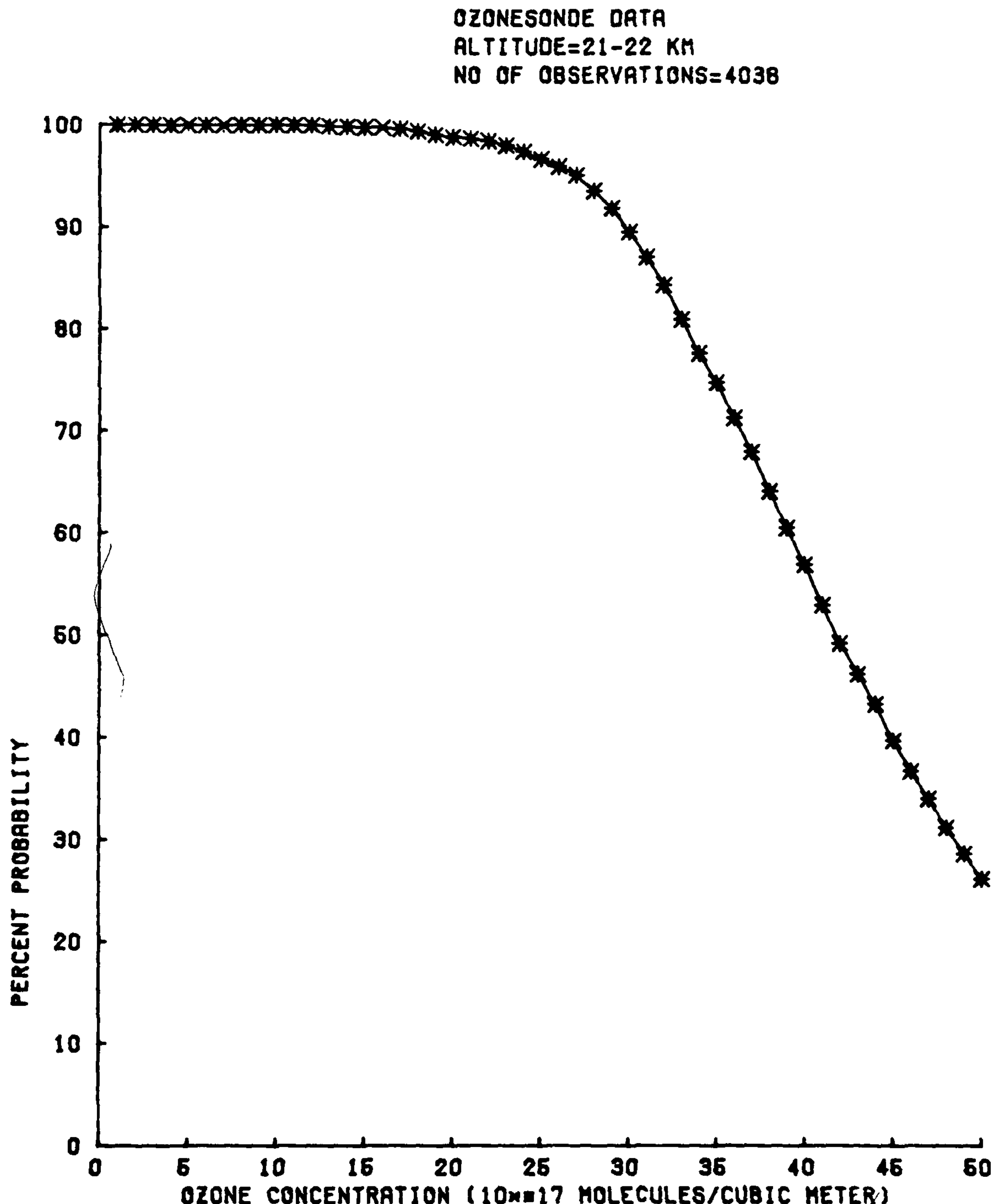

Fig. C22 — Probability of exceeding ozone concentrations for altitudes between 21 and 22 kilometers

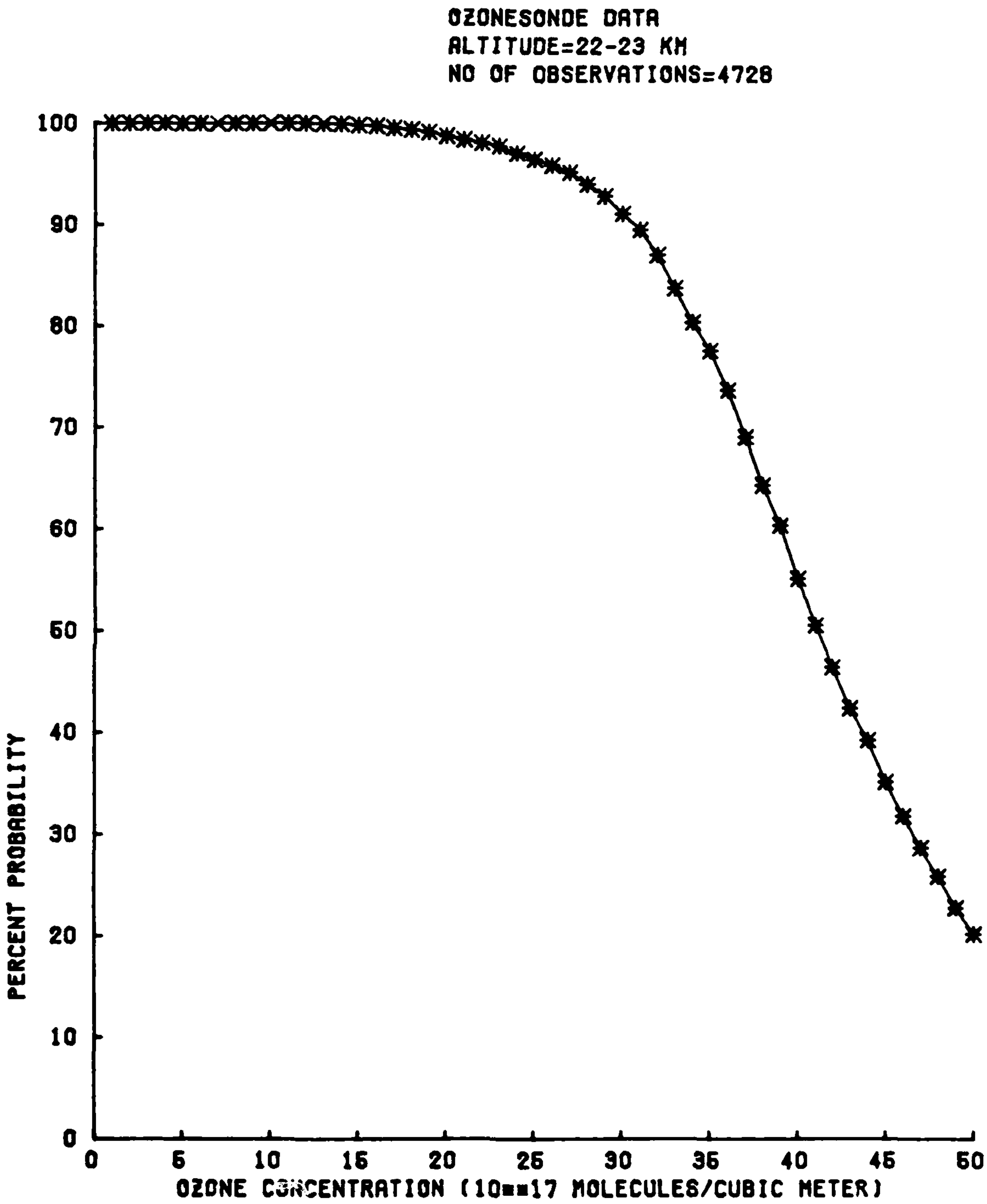

Fig. C23 — Probability of exceeding ozone concentrations for altitudes between 22 and 23 kilometers

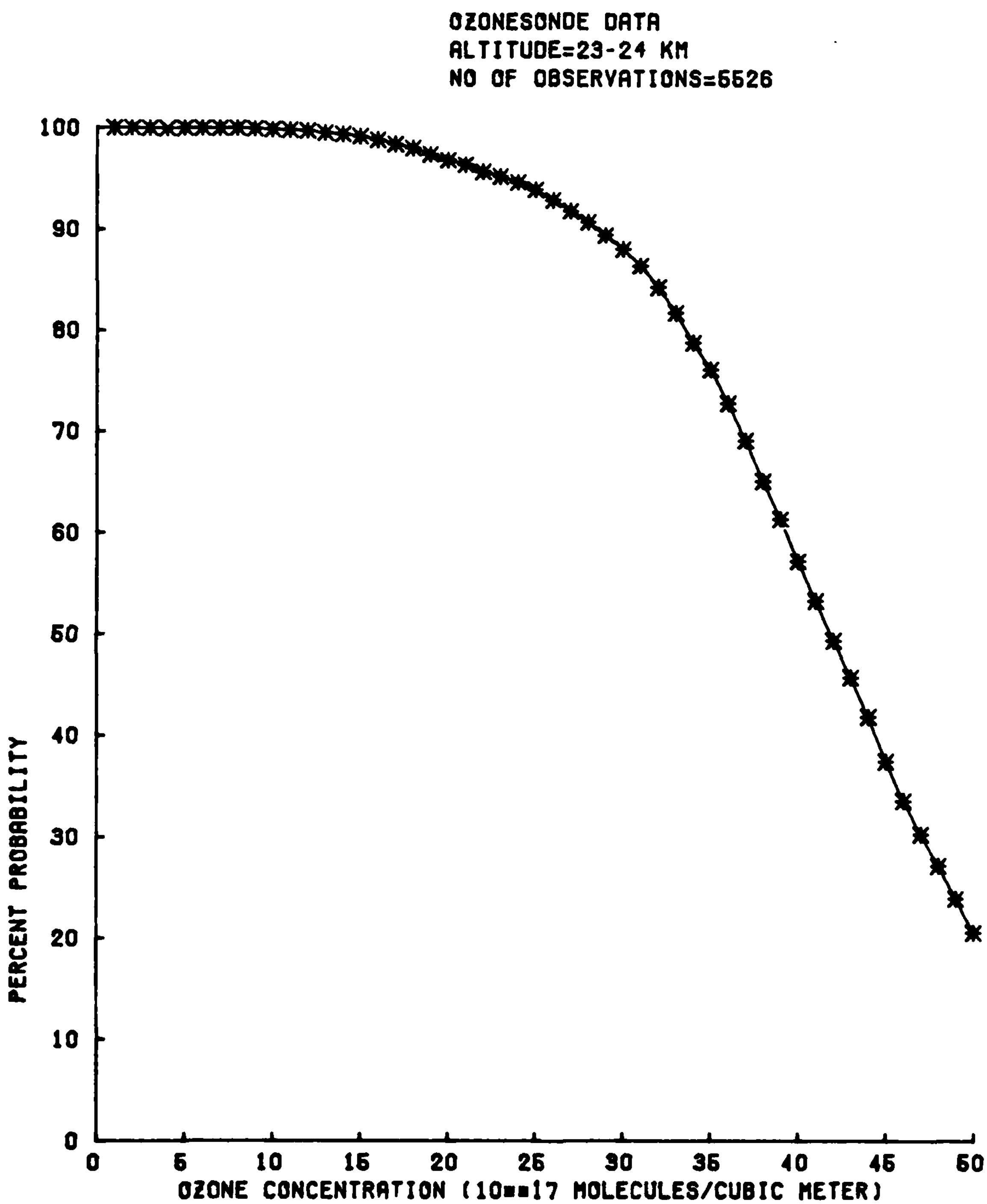

Fig. C24 — Probability of exceeding ozone concentrations for altitudes between 23 and 24 kilometers

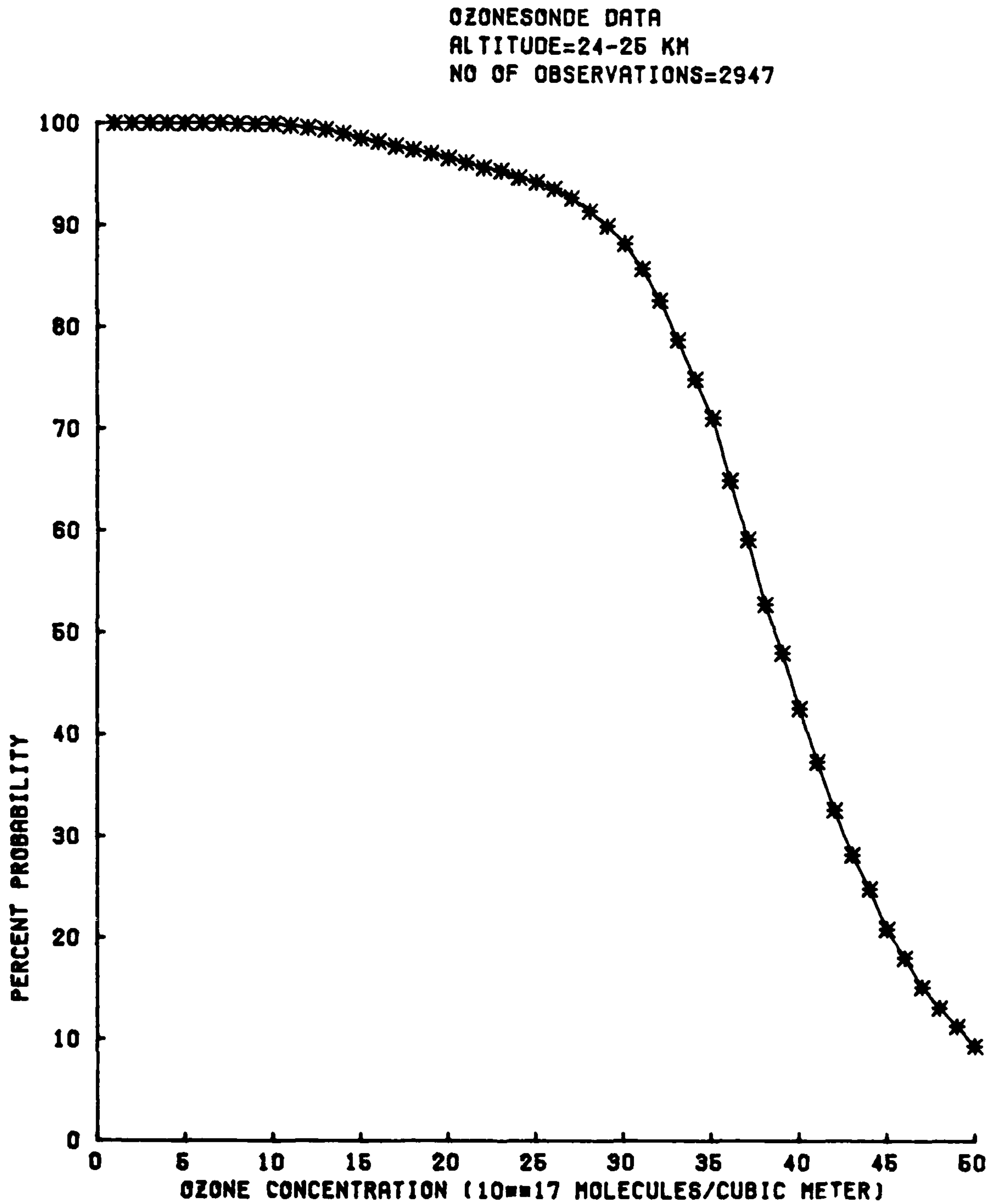

Fig. C25 — Probability of exceeding ozone concentrations for altitudes between 24 and 25 kilometers